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ARCHIVES OF SURGERY

VOLUME 17 OCTOBER, 1928 NUMBER 4

"CHRONIC MASTITIS," "CYSTO-ADENOMA" AND ADENOMA OF THE BREAST

G. LENTHAL CHEATLE, F.R.C.S.

LONDON, ENGLAND

In writing this paper, I have had several objects in view. The first object is to place the so-called "chronic mastitis" in its correct etiologic and pathologic position. Its morphologic appearances are identical with those of the physiologic active state at birth, at puberty and in certain phases of lactation (fig. 1). This active state becomes pathologic (fig. 2) when it is present at from about 30 to 45 years of age and induces diffuse pain, and when fibro-adenomas (usually of the same type as those which form at puberty) develop in its occupied areas (figs. 3 and 4). These two separate occurrences belong to the condition to which the term "chronic mastitis" is so universally applied.

A second object is to point out that the commonest type (fig. 6) of fibro-adenoma that occurs at puberty is a local exaggeration of the physiologic and active hyperplasias which are normal at puberty. A third object is to point out the importance of a state—of formations of epithelial tumors in the ducts and acini—which crops up in the literature, of a pathologic condition in several guises and disguises, including that of "cysto-adenoma." A fourth object is to describe a true adenoma of the breast.

ETIOLOGY AND PATHOLOGY OF CHRONIC MASTITIS

In this part of my paper I shall describe (*a*) the similarity between the normal active morphologic appearances present in the breasts at birth, at puberty and in lactation;[1] (*b*) the etiologic connection between the activity of the breasts at birth, at puberty and in certain phases of lactation, and the morphologic appearances which are now commonly associated with the term chronic mastitis, and (*c*) the etiologic association that exists between the general active changes of the breast at puberty and the formation of the commonest type of fibro-adenoma that arises

1. While writing the results of my investigations, my attention was called to some of the contents of an article by John Fraser (Surg. Gynec. Obst. **45**:266 [Sept.] 1927). I am glad to see that he shares my conviction that the best method of examining breasts is to cut whole sections of the glands—a practice which I have adopted and taught for thirty years. I cut the whole sections in paraffin and not in celloidin.

at that time, which is composed only of the identical tissues that are in a state of active hyperplasia in the normal parts of the same breast.

(*a*) *At Birth and Puberty.*—My conclusions are based on examinations of the breasts of children (male and female) who were born dead; of those who were in the years immediately preceding puberty, and of those who were at the age of puberty. The deaths of many of the children whose breasts were examined occurred at full time and were due to traumatic causes; the conditions of their breasts could not possibly

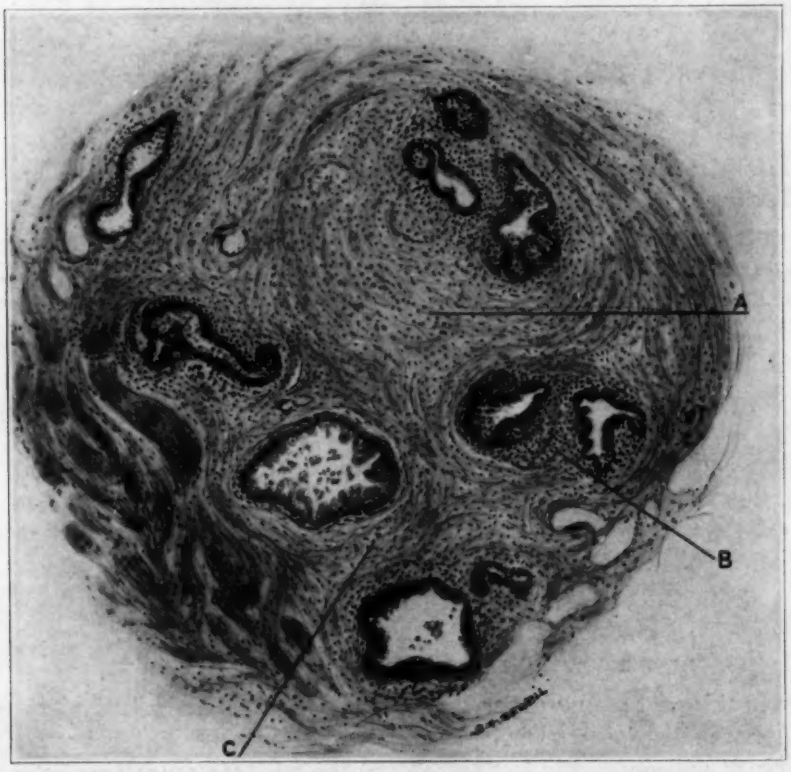

Fig. 1.—Microscopic appearance of part of a male breast at birth—full term. The death was caused by a rupture of the tentorium during birth. At *A*, *B* and *C*, the pericanalicular and periacinous connective tissue is in a state of hyperplasia among the fibers of which lymphocytes have accumulated. There is a desquamative epithelial hyperplasia in the acini and terminal ducts. There is no elastica in this breast. Compare with figure 2.

be assigned to antenatal disease. The morphologic appearances I describe are those of normal active changes and are present in varying degrees in all breasts at birth and at puberty.

It is impossible to distinguish between male and female breasts at birth, but the subsequent changes, at puberty, for example, are more marked in females; therefore, I shall describe only female breasts in

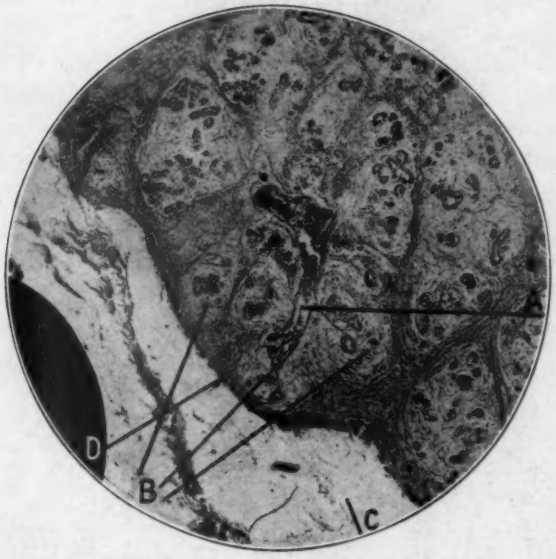

Fig. 2.—Photomicrograph of part of a whole section of breast removed from a married woman, aged 38, who had three children, the youngest being 8 years old. Extreme pain in this breast had been borne for eight or ten years. The photograph has been taken at the posterior margin of the breast *D*. At *D* there is a slight undulation which would not be appreciated by digital palpation. *B* points to a lobule in which there is hyperplasia of the pericanalicular and peri-acinous connective tissue among the fibers of which lymphocytes have accumulated. In the terminal duct *A* there is a desquamative epithelial hyperplasia (type a) which can be seen in the acini. The epithelial hyperplasia is distending these structures. There was no discharge from the nipple. Compare with figure 1.

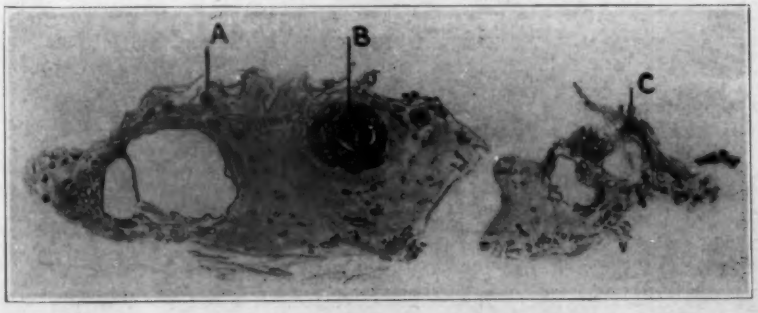

Fig. 3.—Microscopic appearance of section of whole breast which was removed subcutaneously from a married woman, aged 42. Multiple cysts and pain were the cause of its removal. In the more dense looking parts of the section, there were the same signs as those seen in figures 1 and 2. In addition, at *A*, *B* and *C* there were fibro-adenomas in various stages of formation, of which *B* is the most, advanced. They belong to the type of the usual fibro-adenoma which occurs at puberty.

these periods. The changes occur mainly in the terminal ducts and acini, and concern hyperplasia of the epithelial, pericanalicular and periacinous connective tissue.

At birth, the epithelial hyperplasia may be one of two kinds, one type being desquamative and the other formative or genetic. That one type may sometimes be more obvious than the other depends on the stage reached in development. The desquamative type belongs to the

Fig. 4.—Microscopic appearance of the fibro-adenoma *B* in figure 3.

later stage. I will not refer to the formative type here; I may say, however, that these genetic morphologic appearances are like the more dangerous states of dysgenetic epithelium which are seen in pathologic glands in later life.

In the desquamative type of epithelial hyperplasia at birth, to which I now refer, the ducts and acini of the whole breast are filled by small, irregularly shaped, badly staining epithelial cells which have been cast off and are incapable of further life. Also, around the ducts and acini of the whole breast there is an extensive hyperplasia of rather loosely constructed pericanalicular and periacinous connective tissue among the

fibers of which lymphocytes are present (fig. 1). These appearances are constant, and I regard them as part of a normal physiologic process of development.

This enormous activity ceases in the years between birth and puberty and after lactation. After birth and before puberty, the desquamative epithelial hyperplasia ceases; there is often almost a complete atrophy of the pericanalicular and periacinous tissue, and the connective tissue that is more obvious than any other is the ordinary supporting connective tissue of the breast.

At puberty the whole condition seen at birth recurs in more regular and less rampant formation, and lymphocytes also reappear among the increased and actively reforming pericanalicular and periacinous con-

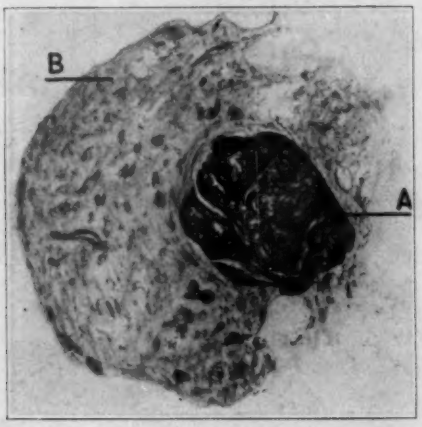

Fig. 5.—Microscopic appearance of a segment of breast removed from a married woman, aged 22, who had noticed the lump *A* for four years. *A* is a fibro-adenoma belonging to the type that usually occurs at puberty. Figure 6 shows *B* in this figure. On the edge of the tumor at *A* there has been an enormous increase of normal looking acini (see fig. 7 *B*).

nective tissue. New acini form and take their part in the enlargement of the breast. After puberty, there is again a great deal of atrophy of the acini and also of the pericanalicular and periacinous connective tissue and a cessation of desquamative epithelial hyperplasia. The appearances of this latent state may remain more or less constant throughout life if lactation does not occur. I now pass on to the merging of these normal changes into pathologic states.

(*b*) *Etiologic and Morphologic Appearances.*—In the first pathologic state, namely, the so-called "chronic mastitis," the morphologic appearances in the epithelium and pericanalicular and periacinous connective tissues are identical with the active states I have described in breasts at birth and at puberty (compare fig. 2 with fig. 1). They are seen between the ages of 30 and 45 in many women and in a few men who

complain of diffuse pain in their breasts. The morphologic appearances in these breasts are those on which the supposed manifestations of inflammation are based. They cannot be regarded as being inflammatory any more than can the same active normal signs which are present at birth and puberty.

Paradoxic as it may seem, "chronic mastitis" is really a physiologic process which has become pathologic by being present when it should be absent, by developing an excess of desquamative epithelial hyperplasia which induces pain by distention (fig. 2 *A*) and by possessing the same liability as the breast at puberty to form fibro-adenomas which may or may not develop acini within their formations of tumor (figs. 3

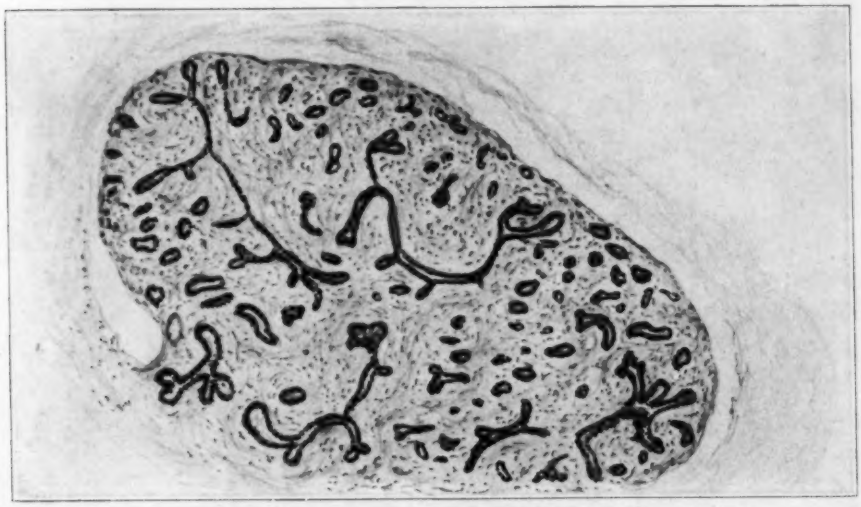

Fig. 6.—Microscopic appearance of a small fibro-adenoma taken from *B* in figure 5. It is the usual type of fibro-adenoma that occurs at puberty and shows the dense hyperplasia of the periacinous and pericanalicular connective tissue.

and 4). For some inexplicable reason, the breasts of some women at any age between 30 and 45 exhibit the state seen at birth and at puberty.

A new and more descriptive name than chronic mastitis is wanted; in my previous communications on the subject I have described it under the heading of "Desquamative Epithelial Hyperplasia type A." I do not look on it as a dangerous state, and it may remain uncomplicated by another pathologic process.

Clinicians are apt to describe these breasts as being nodular all over their anterior surfaces. The posterior surfaces, which are clinically inaccessible, are smooth (fig. 2 *D*). The anterior surfaces of these breasts, and of most breasts of women at this period of life, are presumed to be nodular, for the following reason: As the glands become

Fig. 7.—Microscopic appearance of section taken from the edge *A* of the tumor in figure 5. At *B* there is an enormous increase in the number of acini which do not differ in appearance from those in the rest of the section. The elastica has been stained, and it has undergone a slight irregular hyperplasia around the ducts of the tumor.

pendulous, and especially after lactation, the ligamenta suspensoria of Sir Astley Cooper become thickened. The thickened branches as they approach the skin to which they are attached include fat lobules which are so isolated in the process that they appear as separate nodules. If the skin of these breasts is undercut the cutaneous attachments of these ligaments are divided, and the underlying structures then feel smooth, and nodularity is not found.

(*c*) *Etiologic Association Between Active Changes in Breast and Fibro-Adenoma.*—The second pathologic condition to which I refer is the etiologic connection that exists between the active (figs. 5, 6 and 7)

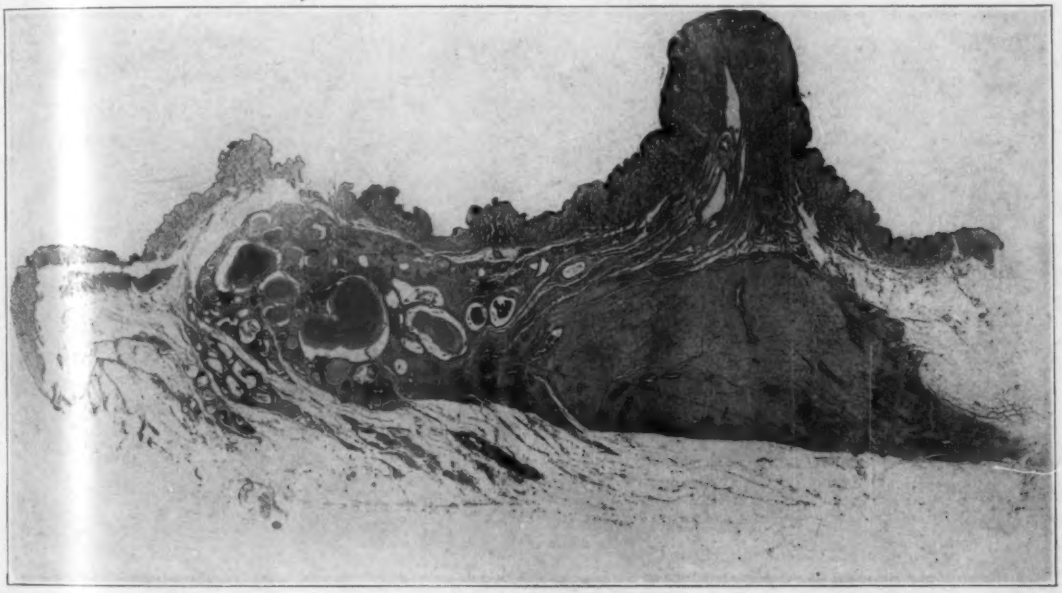

Fig. 8.—Photomicrograph of whole horizontal section of breast from a married woman, aged 36. Removed for the presence of the localized painful nodularity due to the lesion seen on the left of the section. The affected duct and its branches can be seen to be dilated from the prominent nipple in the center of the section to the periphery where there are comparatively large cysts which contain dysgenetic epithelial hyperplasia seen at *A* and *B* of figure 9 and at *A* and *B* of figure 10. Carcinoma is not present in this breast. There was no discharge of any kind from the nipple.

changes at puberty and the formation of that type of fibro-adenoma which is the most common one at that time. Precisely the same tissues which form this tumor are actively undergoing normal hyperplasia in other parts of the breast at the same time; the pathologic difference between the fibro-adenoma and the rest of the breast is that the hyperplasia of the pericanalicular and periacinous connective tissue in the

former, instead of being comparatively loose, is much more dense and compact than in the rest of the breast and affects only a segment of the breast. The size of the segment affected differs in various tumors. The epithelial changes are also those of desquamative epithelial hyperplasia. In some of these tumors of puberty there is also an enormous

Fig. 9.—Photomicrograph taken from figure 8. *B* and *B* is a dilated duct containing papillomatous and sessile dysgenetic epithelial hyperplasia. At *A* there is a collection of acini which are distended by the same type of sessile epithelial growth.

development of acini (fig. 7) which further accentuates a perverted likeness to the physiologic hyperplasia that is occurring in the rest of the breast at puberty. I particularly wish to point out that this tumor commonly begins at puberty and originates in the same tissues that are normally active at puberty. The whole tumor may be regarded as being a more or less localized perversion of a normal physiologic state.

Recognition of the fact that there is an etiologic connection between the pathologic changes I have mentioned and physiologic activity makes a clear and comprehensible point from which to begin consideration of all problems related to the incidence and genesis of pathologic (dysgenetic) hyperplasia.

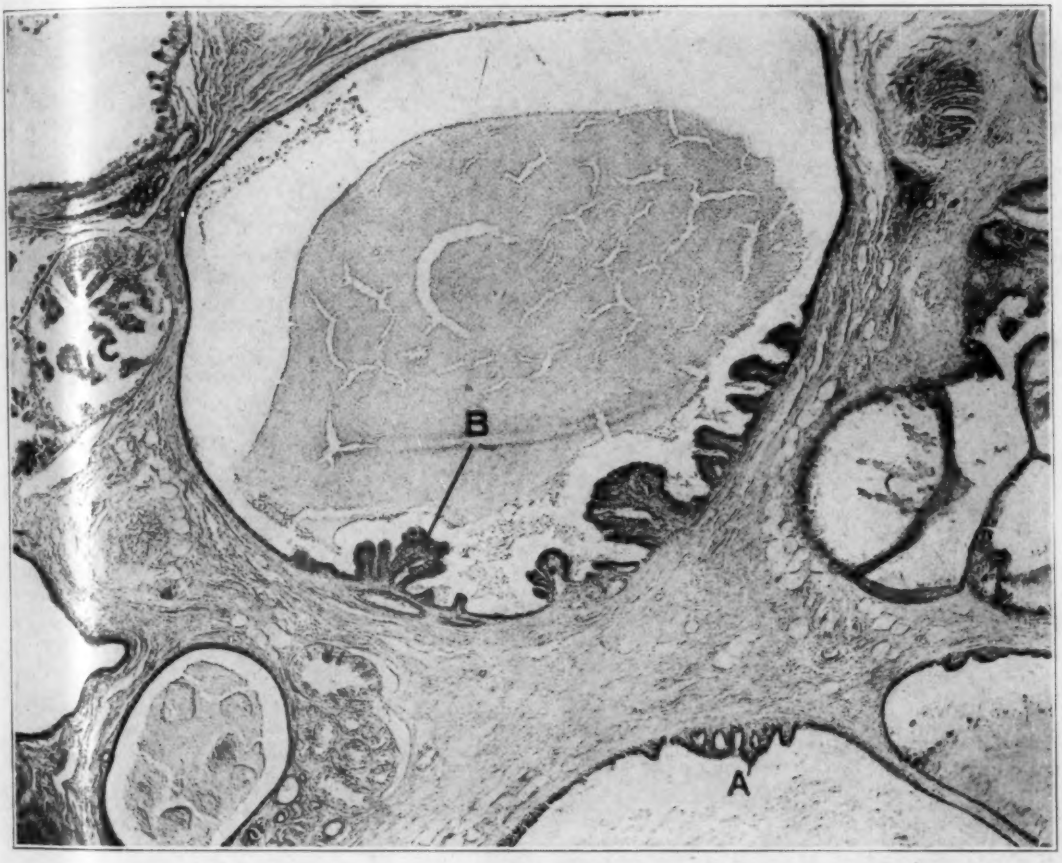

Fig. 10.—Photomicrograph taken from figure 8. In the dilated duct *A* and *B* small isolated origins of multiradicular papillomas can be seen. The epithelial layer covering the tips of some of the stalks has already joined with that crowning the tips of stalks in juxtaposition to each other. Alveolar spaces lined with epithelium are formed in this way. In the dilated acini *C*, the epithelial hyperplasia is passing from the desquamative to the dysgenetic type.

DESCRIPTION OF CYSTO-ADENOMA

My object in this part of the paper is to describe the tumor that is now termed "cysto-adenoma" and to point out that: (1) I do not consider that there is any new formation of acini, and that if there is, it

must be negligible when compared with the new glandular formation that occurs in the adenoma described in the latter part of the paper; (2) that it is commonly composed of a series of separate tumors—papillomas and sessile epithelial growths in preexisting ducts and acini—

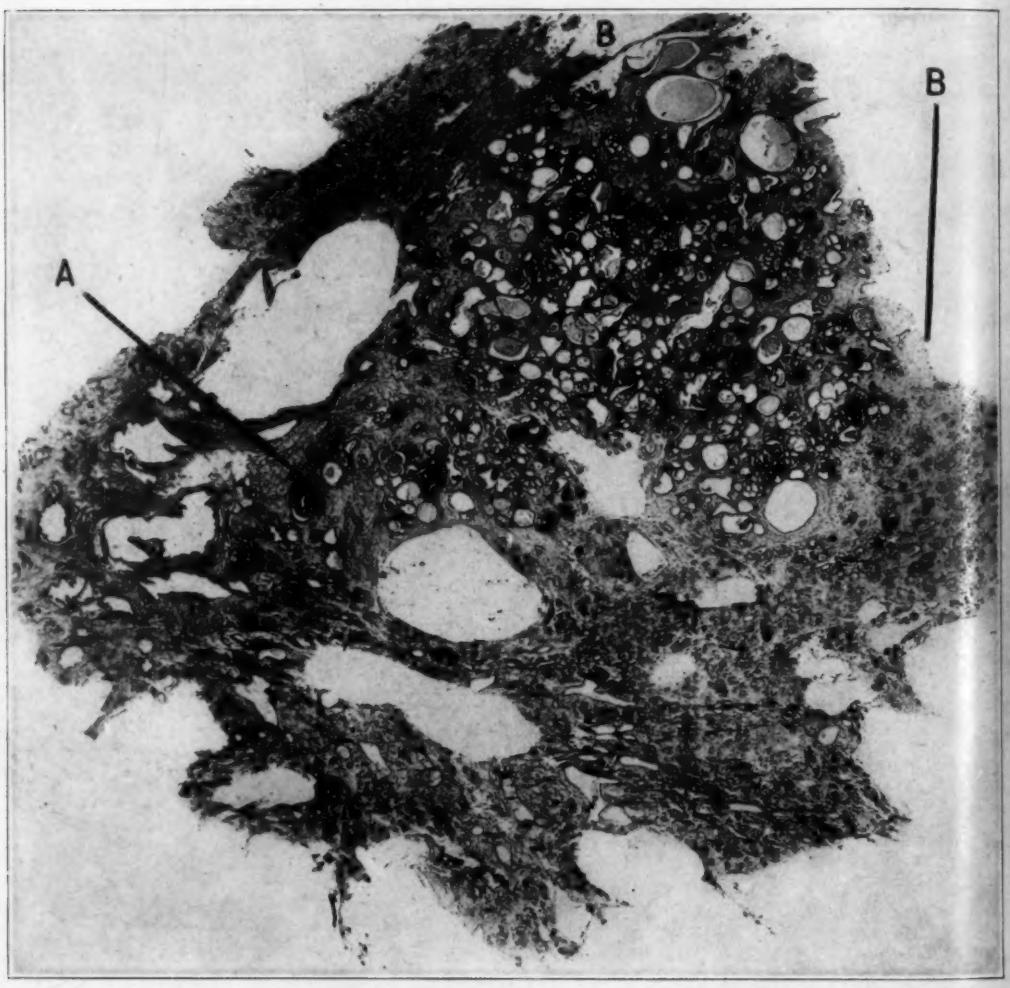

Fig. 11.—Photomicrograph of whole section of breast in which are all the morphologic appearances seen in figures 8, 9 and 10. The section was made vertically in order to show the triangular form of the state described in the text. *A* points to the apex of the triangle in front of which the nipple was situated. The lines *BB* point to the limits of the base of the triangle. The lesion was in the depths of the breast. Palpation revealed only a density in its area of occupation. Carcinoma is not present in this breast. There was no discharge of any kind from the nipple.

and greatly resembles the condition of multiple adenomatous papillomas in the large intestine.[2] In the breast, the epithelial hyperplasia may be more sessile than papillomatous and vice versa; (3) that it is usually a much more diffuse condition than it is generally supposed to be; (4) that it is as full of danger to the patient as the multiple adenomatous papillomas of the colon, and (5) that the term "cysto-adenoma" does not convey correctly the actual state of the tumor. The growths composing the state do not become cystic; they cause only a dilatation of preexisting ducts and acini. The term "cysto-adenoma" appears to me to be a misnomer.

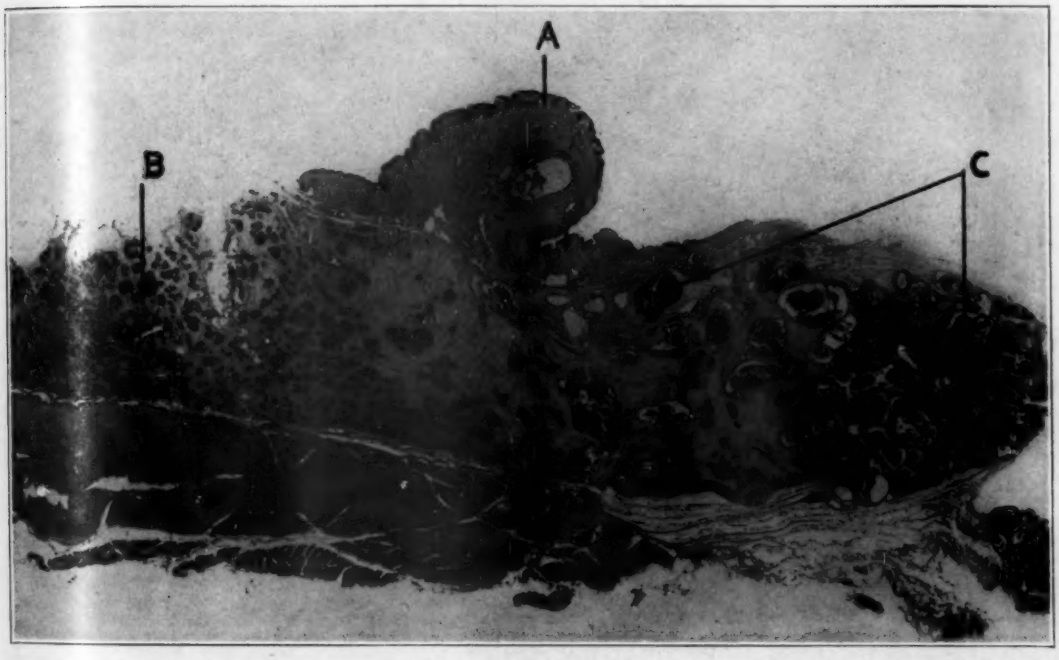

Fig. 12.—Photomicrograph of whole section of breast removed from a married woman, aged 41. Pain and a localized nodularity were present in the part of the breast marked *C*. The lesion occupies the same area as that in figure 8. The duct is also dilated in the nipple *A*, and its dilated branches can be seen directly into its branches which contain the same types of epithelial hyperplasia as figure 8, and on higher magnification in figure 12. There is carcinoma in this breast and the axillary lymphatic glands are not affected (see fig. 14). There was no discharge from the nipple. *B* is the unaffected part of the gland.

In previous communications, I have referred to the state in the cumbersome title of "Intracanalicular and Intraacinous Dysgenetic Epithelial Hyperplasia." The state now so commonly described as a

2. Dukes, Cuthbert: Simple Tumours of the Large Intestine and Their Relation to Cancer, Brit. Surg. **13**:720 (April) 1926.

cysto-adenoma of the breast has no more right to the term than the multiple adenomatous papillomas of the colon, which the changes in cysto-adenoma of the breast so closely resemble. No one suggests calling the condition in the colon cysto-adenoma. The origin of the term as applied to the breast can be explained in the following way: The ducts of the breast are not of large caliber like the tube of the

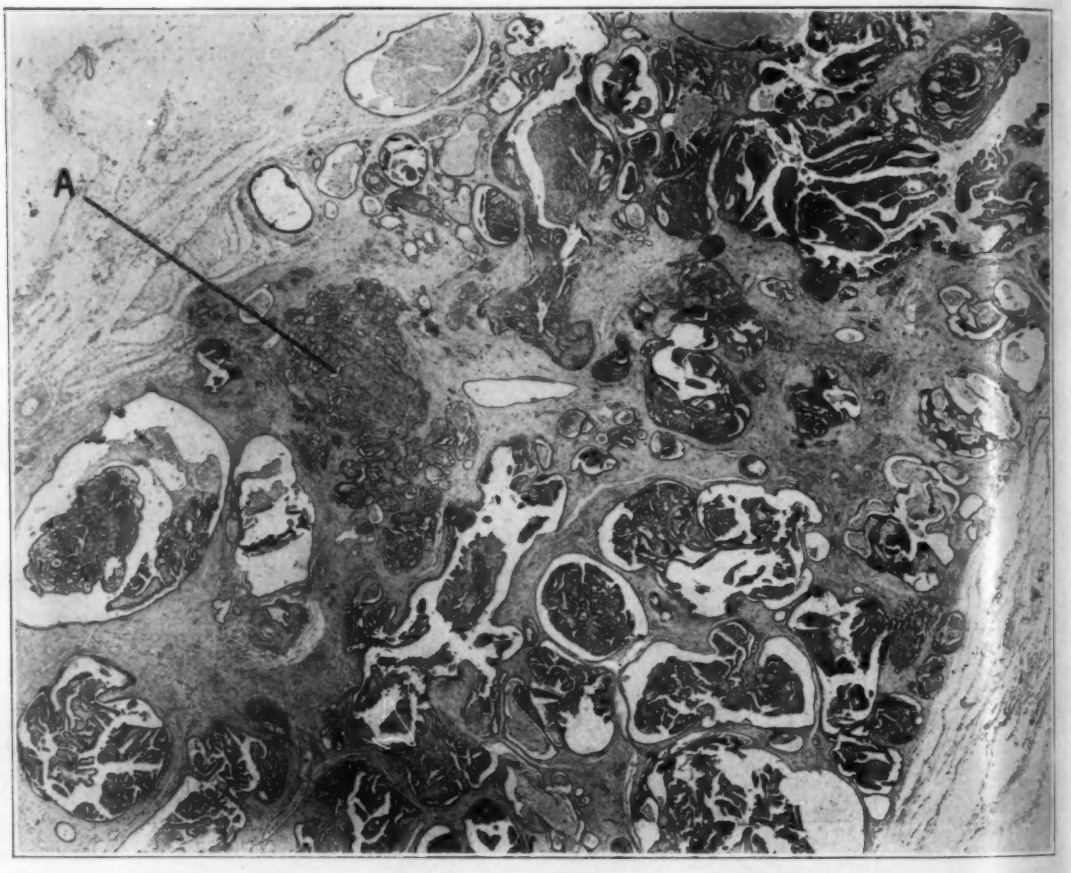

Fig. 13.—Photomicrograph taken from upper and central parts of the lesion *C* in figure 12. The ducts are full mainly of papillomas, and the dilated acini are distended by a sessile epithelial hyperplasia. They are more obvious around the margins of this section. *A* marks the spot in which the carcinoma had begun (see fig. 14).

colon; they are tubes of small caliber which become convoluted and distended and when cut in sections for microscopic examination look like separate cysts, whereas they really are parts of convoluted tubes in perfect continuity. It is important to know all about this state, because it

is often regarded rather casually as being free from danger, whereas, in reality, it is so pregnant with probable danger in all instances and with positive danger in some that when it appears most benign it should be regarded as closely allied to carcinoma as the multiple adenomatous papillomas of the colon. On the other hand it is sometimes described, in exaggerated examples, as being carcinoma, when in reality all the

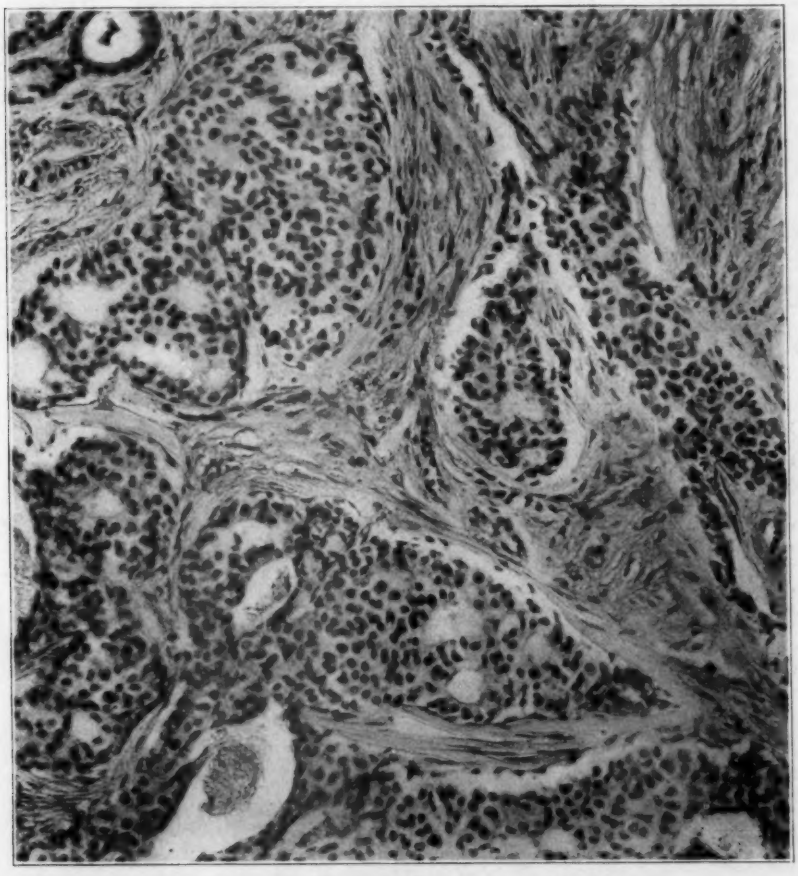

Fig. 14.—Photomicrograph of *A* in figure 13 under high power magnification showing the invasion of the supporting connective tissue of the breast by epithelial cells.

epithelial hyperplasia is contained within normal distended boundaries. It is most important to stain the elastica in all these doubtful conditions in order to see the precise relationship of the epithelium to normal boundaries. The true significance and biologic history of this state have been revealed to me when I have cut whole sections of breasts for microscopic examination and have stained the elastica. In these sections,

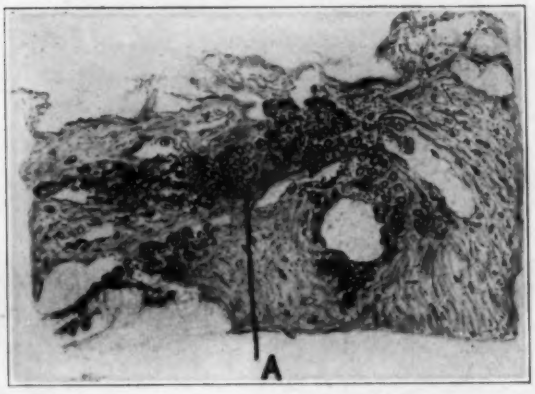

Fig. 15.—Part of a whole section of a breast removed from a married woman, aged 44. Removed for pain which corresponded in situation to an area of density. There was no discharge of any kind from the nipple. The epithelial hyperplasia was papillomatous in the ducts to a much less degree than in the breasts shown in figures 8, 11 and 12, and was much more sessile in character. There is early carcinoma in this breast at *A*, shown in figure 16. The axillary lymphatic glands were not affected.

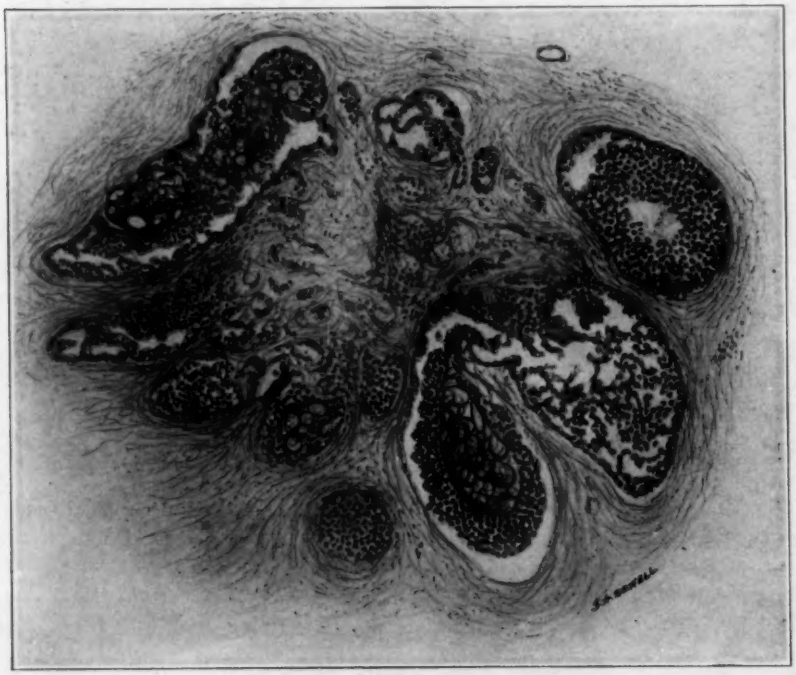

Fig. 16.—Drawing of *A* in figure 15 under higher magnification showing terminal ducts and acini filled with a sessile dysgenetic epithelial hyperplasia. In two of the terminal ducts, it has undergone colloid degeneration. Some epithelial cells have escaped and are invading the connective tissue of the breast.

the complete distribution of the epithelial growth can be seen to be diffuse in the affected ducts much more often than is generally supposed. With the aid of these large sections and also with that of certain clinical features, I will next point out the importance and danger of the subject. Later, I will describe the nature of the epithelial hyperplasia.

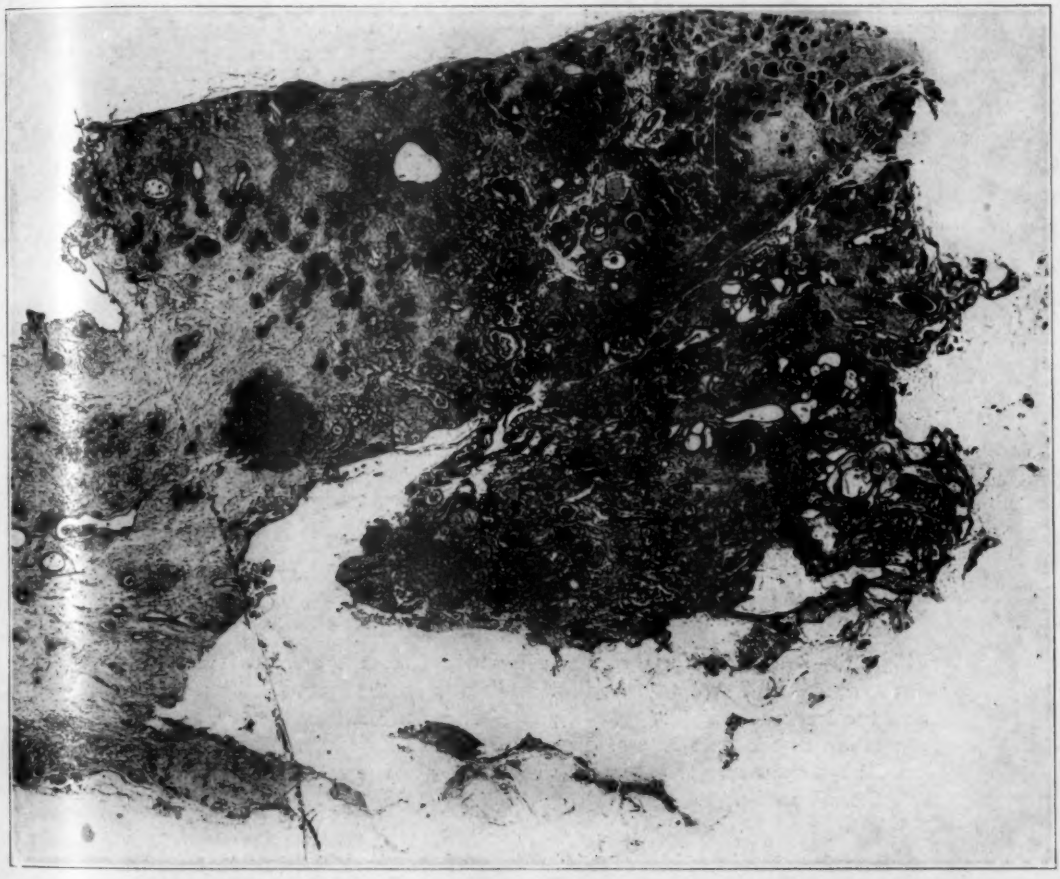

Fig. 17.—Photomicrograph of whole section of breast removed from a married woman, aged 37. The section was made vertically and shows the triangular shape of the lesion. There was a spontaneous occasional and slight discharge of serum from the nipple. Pain was felt in the dense area formed by the lesion situated in the depths of the breast. There was no puckering of the skin over it. Carcinoma existed in this breast, and an enlarged lymphatic gland discovered in the clinical examination contained carcinoma. The epithelial contents of ducts and acini were similar in appearance to those in figures 12, 13 and 14.

In figures 8, 9, 10 and 11 the state is affecting the terminal ducts and acini of one main branch of a duct and its tributaries. Carcinoma

is not present in these breasts. In figures 12, 13, 14, 15, 16 and 17, the distribution of the disease is affecting precisely the same regions. In figure 16, taken from figure 15, and in figure 14, taken from figure 12, there is undoubted carcinoma which has spread among the supporting connective tissue of the breasts and has not affected the fat outside the breast nor the axillary lymphatic glands. The same state may be seen in the ducts and acini of figure 17. In this specimen the carcinoma has invaded the connective tissue of the breast, has undergone colloid degeneration and has spread to one lymphatic gland in the axilla.

When carcinoma does not originate purely in the terminal ducts but when its acini also contain the original malignant epithelial hyperplasia, the state can be seen without exception in every early case of carcinoma of the breast, and sometimes it can be demonstrated—if the elastica is particularly stained—in late cases of carcinoma when nearly

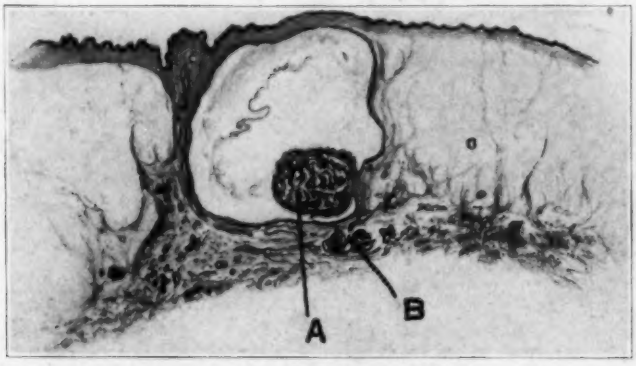

Fig. 18.—Drawing of a whole section made from the breast of a married woman, aged 56. There is a large dilated duct, on the right of the nipple, in which there is a tumor (*A*) with a papillomatous attachment to its wall. The continuation of the duct is also dilated and contains papillomatous and sessile epithelial hyperplasia (*B*). There was no discharge of any kind from the nipple. The tumors were benign.

all the morphologic evidence of its site of origin has been lost in the chaos of growth and spread. Lastly, it is an important and dangerous state on account of its clinical obscurity when it exists in the substance of the breast, both when carcinoma has not begun and also when carcinoma is present in its earliest stages. If the condition appears in a duct the distribution of which is on the surface of the gland, and when there is only a thin layer of fat between it and the skin, as shown in figures 8 and 12, its presence can be detected by a localized triangular nodularity with the base toward the periphery of the gland (figs. 11 and 17). I cannot exaggerate the importance of local nodularity as a clinical sign. When it affects a surface diet and when the layer of fat

between it and the skin is thick, its clinical signs on palpation resemble the same condition when it is in the substance of the gland. In both these instances it appears as a localized lesion, harder than the rest of the gland and incapable of further diagnosis by palpation. Pain that usually accompanies this state is always referred to this denser area of the breast. There may also be a history of an intermittent discharge of

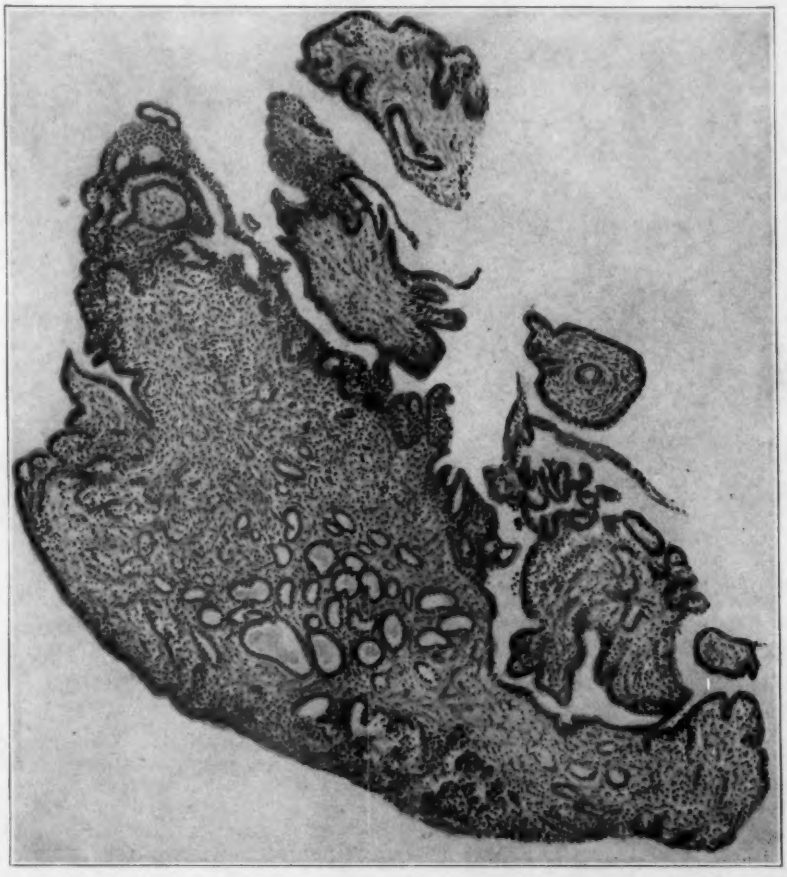

Fig. 19.—Tumor *A* of figure 18, showing changes which may occur in papillomas. In this specimen there are acinous and duct reproductions in the tumor.

blood or of serum from the nipple. In the later stages, when it has progressed to advanced carcinoma, it will pucker the skin, the lymphatic glands will be affected in the axilla, and a complete picture of advanced carcinoma will be present.

PATHOLOGY

A normal duct in the breast consists of a main duct, which in the depth of the breast divides into two, a long branch diminishing in caliber

as it traverses the gland to reach the periphery and a short branch directed backward to reach the posterior surface of the gland. Throughout the courses of ducts, lobules of acini are connected to them by smaller ducts. During lactation, the nipple is crammed with acini and is distended to so great an extent that morphologically they appear to be the main constituents of the nipple. After lactation, they disappear completely.

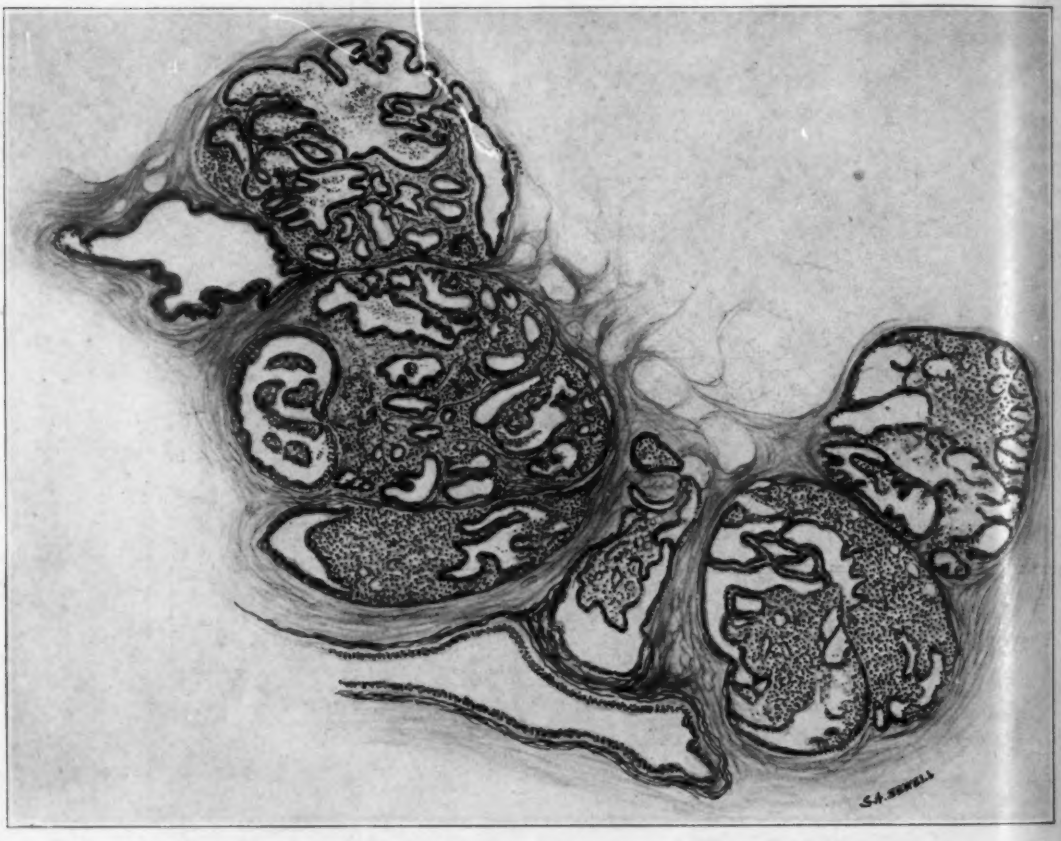

Fig. 20.—Tumors *B* situated lower down in the same duct *A* of figure 18. The papillomas have undergone the same development into glandular reproductions of less typical character compared with *A* in figures 18 and 19.

The epithelial hyperplasia of this so-called "cysto-adenoma" may exist only in the duct as it passes through the nipple or only in the ampulla of a duct, or it may exist only in the main branch before it divides (figs. 18 and 21). On the other hand, it may extend throughout the whole course of a duct from the ampulla to its periphery and involve the acini to such an extent that they all contain some form of

the dysgenetic epithelial hyperplasia. I have a specimen—presented to me for examination by Mr. Sampson Handley—in which the whole lengths of two ducts and their acini are involved in this manner. Again, only one of the main branches may be thus affected throughout its course (figs. 8, 11, 12, 13, 15 and 17) or even a few or only one of its terminal branches and acini may contain the epithelial hyperplasia. There are no clinical signs on which a limited distribution can be diagnosed from an extensive one, and no one can tell from clinical signs whether he is dealing with a growth only in the ampulla or

Fig. 21.—Photomicrograph of a whole section of breast removed from a married woman, aged 46. There is a large tumor dilating a main duct and growing upward into the nipple. It presents the same morphologic characters as those seen in figure 19. There was a spontaneous and intermittent discharge of blood from the nipple. The tumor is benign.

whether growths are closely scattered throughout the whole course of a duct. The nature of the epithelial hyperplasia subject to modification is the same in all. The epithelial hyperplasia is dysgenetic and not desquamative. It may be a mixture in which papillomas are much more in evidence than sessile growths and vice versa, or each may grow pure in type. When it is purely sessile, I regard the tumor as more danger-

ous even than the purely papillomatous type. In the ducts the epithelial hyperplasia behaves a little differently from that in the acini. It may affect the duct in two ways. First, it may be papillomatous. When the tumor is of this type it arises in a multiradicular manner from many stalks of fibrous tissue which are usually composed of the whole wall of the duct, and the elastica can be stained in their centers (figs. 10 *A* and *B*); or, less commonly, it may arise from the intra-elastica connective tissue, when there is no elastica in the stalks. However papillomas arise, they are always covered by the columnar epithelium of the duct. The papillomas arising from the intra-elastica do not branch so freely as those which contain the elastica; they remain small, and epithelium piles itself on the top of them. The papillomas containing the

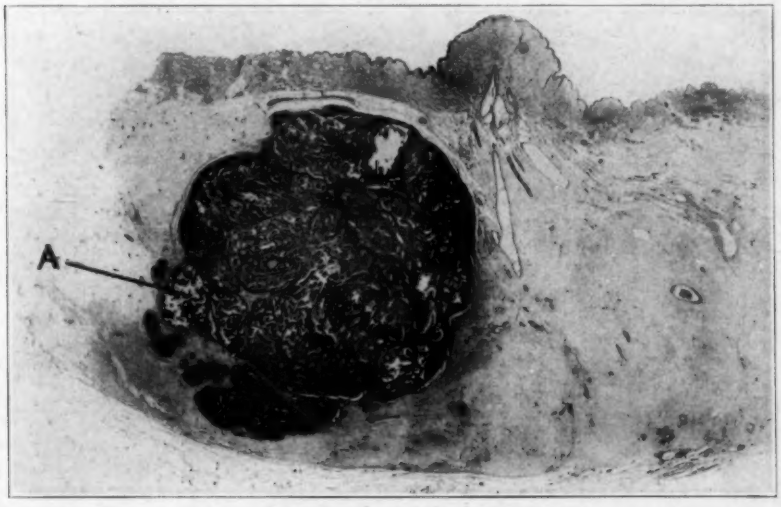

Fig. 22.—Photomicrograph of whole section of breast removed from a married woman, aged 48. The main part of the epithelial hyperplasia is confined within the boundaries of normal ducts and has a decided papillomatous arrangement of less orderly character than that in figures 18, 19, 20 and 21. At the lower left part of the periphery of the tumor, epithelial cells have invaded the connective tissue. There was no discharge of any kind from the nipple, and the axillary lymphatic glands were not affected.

elastica may undergo various changes. They may appear as small growths, but usually they branch extensively and the epithelium on the tips of their branches coalesces with branches of the parent papilloma and with those of contiguous stalks to form alveoli lined by epithelium (figs. 10 *A* and *B*). A papilloma may more rarely develop into an arrangement which constitutes a small mammary gland or adenoma containing ducts and acini (figs. 18 and 21). When this process occurs,

it usually takes place in the main duct. It is interesting to observe that all the epithelial and glandular elements of this particular intracanalicular tumor (figs. 19 and 20) are derived from the columnar cells which originally lined the duct.

Fig. 23.—Photomicrograph of *A* in figure 22. The disordered papillomatous arrangement can be seen in duct papilloma (*A*). Epithelial cells have grossly invaded structures outside the duct at *B*.

Similar complete glandular formations do not occur in acini. There can be no doubt that an intracanalicular adenoma of this kind may con-

tain a carcinoma; for example, it is hard to believe that all the epithelial changes seen in *A*, in figures 22 and 23, in which carcinoma is present, did not begin in this way, and it is probable that the advanced carcinoma in figure 24 is an advanced tumor which had the same origin. Accompanying the papillomatous tumors there is generally a sessile epithelial hyperplasia without any fibrous stalks, which may completely fill a portion of a duct. Sessile and papillomatous formations are commonly seen together when long branches of ducts are affected. Sometimes the sessile epithelial hyperplasia is more in evidence than the papillomatous. If that is so, the state is more dangerous than if it were chiefly papil-

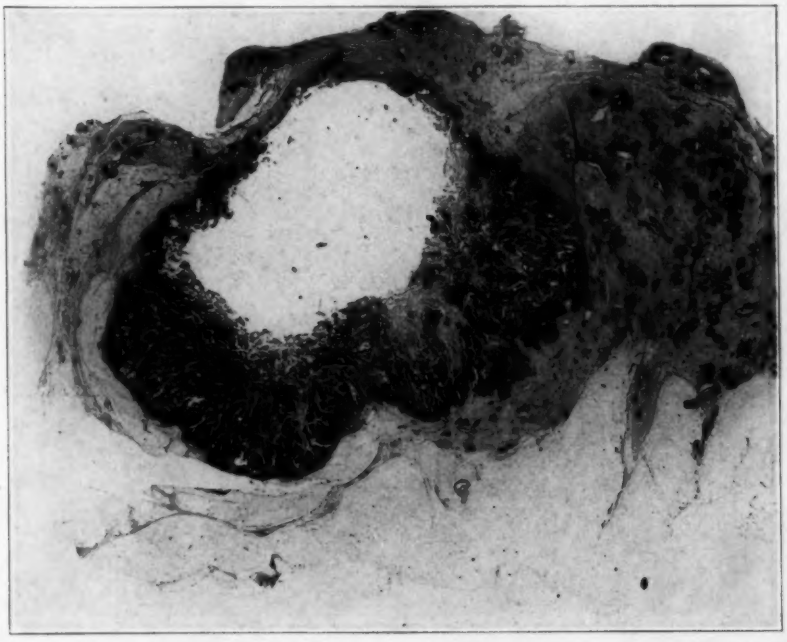

Fig. 24.—Photomicrograph of whole breast removed from a married woman, aged 36. There was no discharge of blood from the nipple. Lymphatic glands in the axilla contained carcinoma. The patient died of the disease eight months after the radical operation. The extension of this carcinoma was one of the most rapid and diffuse the author has seen. The appearances suggested a papillomatous arrangement, and the epithelial cells were columnar. The three tumors depicted in figures 18, 19, 20 and 21 appear to be benign examples of a state which may pass on to the malignant condition seen in figures 22, 23 and 24.

lomatous. For instance, when only a terminal duct and its acini are affected, the epithelial hyperplasia may be only sessile in the ducts and acini. The acinous papillomas are not so common, and when they occur they are composed of fine fibrillous stalks which do not branch

and are generally associated in the same acini with a sessile epithelial hyperplasia. As I have just stated, none of the newly formed and complete glandular elements are seen in acini. The glandular development of such a lesion is capable of developing only from columnar epithelium of a duct. Whether or not it is called cysto-adenoma, this condition is essentially one in which separate tumors appear as intra-canalicular and intra-acinous epithelial growths which do not become cystic.

I have said enough to justify the following statement: It is important that the condition should never be considered benign when only a

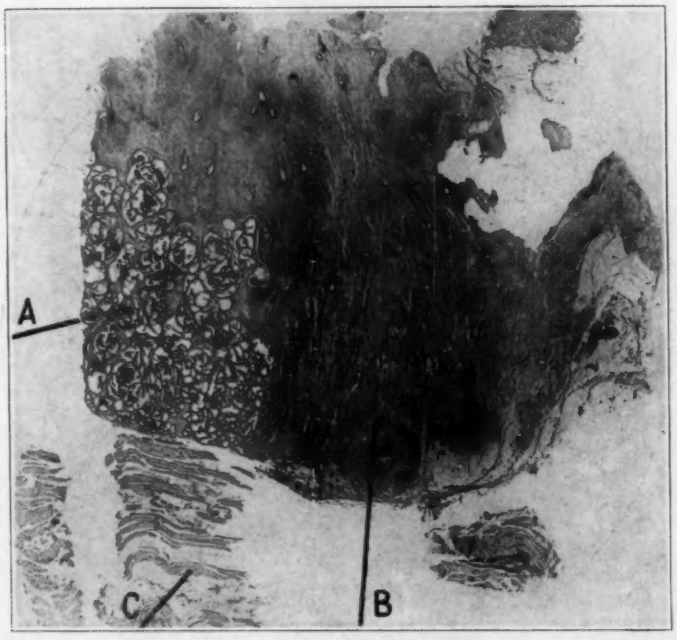

Fig. 25.—Photomicrograph of part of a breast removed from a girl, aged 15. The tumor is benign and does not contain evidence of even a doubtful invasion of epithelial cells. It consists of pathologic adenomatous tissue consisting chiefly of ducts *A*, in the interiors of which there is a great deal of papillomatous formations in the centers of which the elastica can be stained and is continuous with the elastica of the duct walls (see fig. 26). There were no enlarged lymphatic glands in the axilla. *B* is the unaffected part of the breast and *C* is the pectoralis major.

part of the lesion is examined. It would be safer to remove the whole gland and its lymphatic connections than to trust to the results of a partial examination. On the other hand, the changes I have described in the ducts and acini are commonly depicted in textbooks as being carcinoma itself, although if the elastica is stained, it can be demonstrated that the epithelial hyperplasia is confined within normal but

distended boundaries. The changes may exist in a breast in which carcinoma is not present. There are examples in which at some place or other the epithelial cells have invaded outside structures and unsuspected carcinoma is present (figs. 2, 13, 14, 15 and 16). It is difficult to discover the focus of exit of these invading cells, even after examination of sections carefully cut in series.

PURE ADENOMA OF THE BREAST

My object in this part of the paper is to describe the purest type of adenoma I have observed in the breast. It is a rare and benign

Fig. 26.—A representative part of the adenoma *A* in figure 25.

tumor. On the one hand, it differs from the cysto-adenoma by a massive new formation of pathologic adenomatous elements—a new formation of ducts and acini does not occur in cysto-adenoma. On the other hand, the pure adenoma differs from a fibro-adenoma, in which a new formation of ducts and acini may occur (fig. 7), by a complete absence of the dense hyperplasia of the pericanalicular and periacinous connective tissue which is characteristic of fibro-adenoma (fig. 6). The pure adenoma resembles the cysto-adenoma by exhibiting papillomatous and sessile epithelial hyperplasia which dilates the structures in which it grows. The feature which distinguishes the pure adenoma from all

other tumors of the breast is that it consists only of a massive new pathologic formation of ducts and acini. The new formation of ducts (fig. 25) may be more excessive than the new formation of acini (fig. 27) and vice versa. I do not know whether this tumor can become malignant. I have seen only two examples. One was a tumor and part of a breast from a girl, aged 15 years (fig. 25). The tumor was composed of a massive new formation of pathologic adenomatous elements in which formation of new ducts predominated. Within the ducts papillomas had grown (fig. 26). The elastica was continued from the

Fig. 27.—A part of the adenoma which grew in the breast of a married woman, aged 34. There were no affected lymphatic glands in the axilla, and the patient was well twenty years after the operation. The tumor was composed of adenomatous tissue consisting chiefly of acini which were dilated; some contained delicately built papilloma; others, sessile tumors; others, short columns of epithelial cells piled on the top of each other, and others were lined with regularly arranged cuboidal shaped cells. The tumor was benign although it did not possess a limiting wall in which it resembled the adenoma depicted in figure 25.

walls of the ducts into the centers of these papillomas. A sessile epithelial hyperplasia was also present in some of the ducts. There was a marked absence of connective tissue in the tumor (fig. 25). Clinically, the tumor grew rapidly and is said to have doubled in size in six weeks.

At the operation, the tumor was as large as the girl's fist. Enlarged lymphatic glands were not found in the axilla, and the girl was well two years after the operation.

The second example of this type was a tumor removed from a married woman, aged 34, who had three children. The microscopic appearance of this tumor is shown in figure 27. The tumor consisted of a massive new formation of pathologic adenomatous elements chiefly composed of dilated acini. They may lie in juxtaposition or they may be separated from each other by loose connective tissue. The epithelial elements may consist of a simple layer of cuboidal shaped cells. The cells may pile themselves on the top of one another to form columns three or four cells in height, and the epithelial cells may grow on delicate fibrillous stalks to form papillomas which do not branch. Collections of cells may be sessile (fig. 27).

Clinically, the tumor was growing. The exact pathologic state was not clear at the operation, and the gland was removed as for carcinoma. Microscopic examinations proved that none of the axillary lymphatic glands was affected. The patient was well twenty years after the operation.

CHRONIC ULCERATIVE COLITIS ASSOCIATED WITH MALIGNANT DISEASE*

J. ARNOLD BARGEN, M.D.
ROCHESTER, MINN.

The term "chronic ulcerative colitis" has come to mean a definite disease entity, which presents characteristic clinical, pahologic, proctoscopic and roentgenologic data. Clinically, the disease is characterized by frequent rectal discharges of mucus, blood and pus; the presence of diarrhea depends on the extent of involvement of the colon and the severity of the disease. Usually the infection begins in the rectum and spreads upward, and frequently affects the entire colon. If, therefore, the lesions involve only the rectum and rectosigmoid, the stools may be scybalous and the patient may complain of constipation, while having twelve or more bloody, purulent rectal emissions daily. The result of the long-continued passage of blood and the toxemia from the severely infected colon is general wasting, anemia, emaciation and, eventually, chronic invalidism.

Obviously the symptoms of this disease may be readily confused with other conditions in which mucus, blood and sometimes pus are discharged from the rectum; namely, amebic ulceration, tuberculosis and carcinoma of the colon. Until the organism (described elsewhere [1]) was isolated, the two essential and only aids to diagnosis of proved value were the proctoscope and the roentgen ray. Buie [2] described the typical proctoscopic picture. Carman and Moore [3] showed that the roentgenographic picture is pathognomonic.

An organism of characteristic morphologic and biologic properties has been isolated repeatedly by Torrey,[4] Houston,[5] Soper,[6] Jones,[7] Fansler,[8] DeBere,[9] Cook,[10] myself and others, and the injection of this

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* From the Division of Medicine, Mayo Clinic.

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organism into animals has produced lesions in the colons of rabbits and dogs in all essentials like those found in man. Thus, the disease has been established as an infection of the colon, and for want of a better term the original designation of chronic ulcerative colitis or colitis gravis has been retained.

The infection of the colon is severe and carries with it serious complications and sequelae, such as polyposis, perforation, stricture, hemorrhage, perirectal fistula and abscess, endocarditis, splenomegaly, mesenteric thrombosis, ocular phenomena, tetany, severe anemia, arthritis and malignant disease. The malignant condition, although not common, is undoubtedly the one most dreaded.

In the records of the Mayo Clinic from 1916 to 1927, inclusive, I noted reports of twenty-three cases of chronic ulcerative colitis in which it was believed, because of various clinical and pathologic signs and symptoms, that a malignant disease of the colon had developed. Post-mortem examination in three of these cases failed to reveal malignant disease. There was, instead, extensive ulceration and polyposis. In three others the proof was large filling defects in the colon, with sudden and rapid change of symptoms, obstruction, cachexia and anemia. A specimen for diagnosis was not obtained. In the remaining seventeen cases the condition was proved to be malignant, either by the specimen removed or at necropsy.

I shall include in my discussion, therefore, twenty cases of malignant disease, the seventeen in which the condition was proved by examination of tissue and the three in which it was proved by clinical diagnosis. The age incidence in these cases is significant. Whereas five patients had attained the age of 50 or more, the other fifteen were between 21 and 45 (three were aged 21, 23 and 26 years, respectively; six were between 30 and 39; six were between 40 and 45). Only one patient (a woman, aged 53) gave a history of malignant disease in the family: two uncles had had carcinoma. Nineteen patients were white; one was a mulatto. Fourteen patients were farmers; one was a laborer, one a railroad conductor, one a lawyer, one the wife of a physician, and two were bookkeepers. Symptoms of chronic ulcerative colitis were complained of for from three months to thirty-five years before admission. Only one patient had had symptoms for thirty-five years; the average duration of symptoms of the other nineteen was six years.

The medical treatment had varied, as is usual in these cases. In a few cases, injections of vaccine had been given subcutaneously; in most of them, rectal irrigations with one or another of the so-called intestinal antiseptics had been given.

In most of the cases, a fairly definite change of symptoms could be elicited by which the beginning of the malignant process could be esti-

mated. In nineteen of the series of twenty cases, there was a recent rapid loss of weight; in seventeen, the pain and cramps in areas along the course of the colon increased in intensity somewhat abruptly; in twelve, the clinical signs of varying degrees of obstruction were noted; in ten, there was a sudden progressive increase in the amount of bloody rectal discharge; in ten, there was an appearance of greater visceral degeneration; in seven, noticeable cachexia developed; in four, an abdominal mass was palpable; in three, increased urgency and straining were present, and in a considerable number, peculiar pallor was noted, although in only seven was the hemoglobin below 50 per cent; in general, the hemoglobin was not lower than that in most persons with chronic ulcerative colitis.

In the roentgenograms in eight cases, besides the characteristic appearance of chronic ulcerative colitis, shadows of definite filling defects were noted in various parts of the colon, along the course of the ulcerative process. The position of the filling defect was not characteristic, the malignant lesion occurring almost anywhere in the colon, although not at the splenic flexure. In all cases the proctoscopic picture was that of severe chronic ulcerative colitis. In seven cases, benign polyps were present in the rectum. In seven, grossly malignant lesions were seen through the proctoscope (in four of these, polyps were also present).

In a recent review [11] of 200 cases, polyposis in the later stages of the disease was noted in 13 per cent.

Of the twenty cases reported in this series, there were fourteen cases of proved carcinoma, two of lymphosarcoma, and one of lymphatic leukemia; in three, the condition was diagnosed as carcinoma, either by proctoscopic or roentgenologic evidence. In six cases, the carcinoma was multiple in the colon; in one case, there was diffuse carcinomatosis along the entire length of the colon, the cells showing a high degree of malignancy. Wherever there were islets of regenerating mucosa, they were malignant. In most of these cases the carcinoma was of a high degree of malignancy. The multiple carcinomas were of a higher degree of malignancy than the single, being graded, according to Broders' classification, 3 + and 4.

Fifteen patients were operated on and twelve died: seven of generalized purulent peritonitis, two of pneumonia and three of metastasis. Two other patients were treated by radium with definite shrinkage of the tumor in one instance. The patient who had lymphosarcoma was living a year after the resection.

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REPORT OF ILLUSTRATIVE CASES

CASE 1.—A boy, aged 9 years, first came to the Mayo Clinic in 1915. He had suffered with diarrhea for a year or longer, and was passing from five to six stools a day which contained much blood, mucus and pus. As he lived only twenty miles from Rochester, he visited the clinic during the following ten years whenever the trouble became severe, which was several times each year. On his first visit he was placed on treatment for amebiasis, which consisted of emetine, hydrochloride, administered hypodermically, and irrigations of coal-oil. Repeated examinations of the stools did not reveal amebas or parasites of any kind. A diagnosis of colitis was made proctoscopically. Every cold caused an exacerbation of the colitis, and the patient had colds and tonsillitis at all seasons of the

Fig. 1 (case 1).—Roentgenographic appearance of the colon after a barium enema in 1924.

year. Finally, in July, 1924, he was brought to the clinic in an exhausted condition with severe bronchitis and had to be taken to the hospital at once. At this time he said that as long as he could remember he had never passed fewer than six or eight stools in twenty-four hours and that they were always mixed with blood. For weeks after he had a cold, he passed from fifteen to twenty-five stools in twenty-four hours, with severe cramps and tenesmus before and during each passage.

Successive examinations of the stools for endamebas and acid-fast bacilli again gave negative results, but by culture of the scrapings from the bases of the ulcers many gram-positive diplococci were found. The patient had a low grade fever and the maximal leukocyte count was 19,300. The proctoscope revealed active ulcerative colitis, graded 4. Roentgenograms of the colon showed that it was shortened and tubelike (fig. 1). The patient had the pasty appearance of a

person with visceral degeneration. His weight, which at the maximum had been 135 pounds (61.2 Kg.), was now 120 (54.4 Kg.).

The patient recovered slowly from the bronchitis, and by palliative measures the stools were gradually reduced in number. About this time (October, 1924) a perirectal abscess developed, and from the pus of this abscess a pure culture of the diplococcus was recovered. From this time the treatment consisted of autogenous vaccine, tincture of iodine by mouth at intervals and local medication in an effort to eradicate the perirectal pus pocket. The treatment was continued at intervals until March, 1925, the patient improving steadily. In August, 1925, and again in October, he appeared to be entirely well on proctoscopic and clinical examination. A roentgenogram of the colon taken in August showed persistent contraction but a partial return of haustra. The weight was 153 pounds

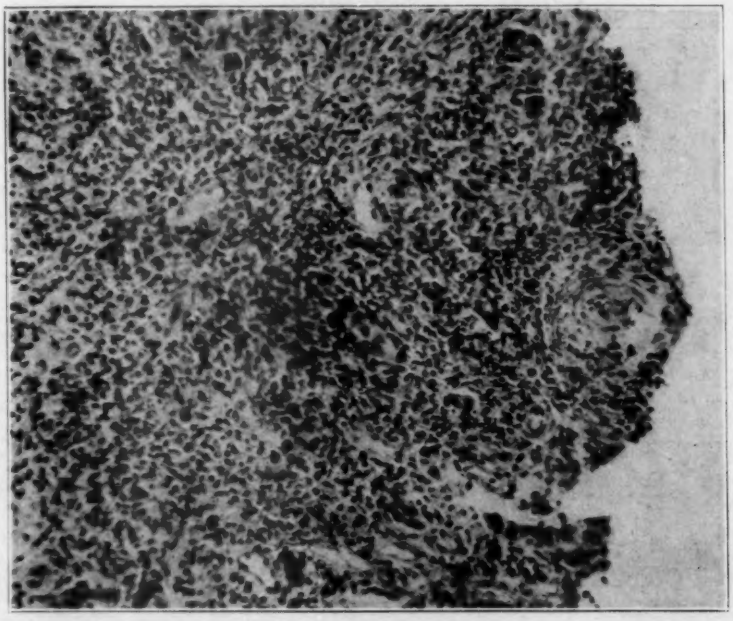

Fig. 2 (case 1).—Section of rectal tumor removed in January, 1928; × 150

(69.4 Kg.). The patient felt well and was doing a man's work at the age of 19, whereas he had never worked before. He remained well until the autumn of 1927, when he began to lose weight and passed blood by rectum. A digital examination revealed roughened areas of the mucosa. Close observation of these areas proctoscopically and clinical observation of the patient soon revealed a definite change. He appeared exhausted and cachectic. Biopsy of one of the small heaped-up mucosal tufts showed adenocarcinoma, graded 4 (figs. 2 and 3). It seemed best to use radium; several applications caused definite shrinkage of the lesions as well as a beneficial effect on the surrounding mucosa. At this time a lesion of the throat developed, suggestive of Vincent's angina, but it did not respond to the usual treatment for this condition. The lesion progressed until pharyngeal paralysis resulted. General failure was rapid and progressive, and the patient died five months after what appeared to be the onset of the malignant condition.

CASE 2.—A man, aged 26, came to the Mayo Clinic on Oct. 2, 1925. He said that about ten years previously he began to have bloody purulent rectal discharges with frequent watery stools. At first this occurred at intervals with remissions. In 1917, he was well enough to be admitted to the army, although he did not tell the members of the examining board of bowel trouble. While in the army he spent most of his time in the hospital, a severe exacerbation having occurred in 1917. He passed from twenty to twenty-five bloody stools daily, many of them at night. He had been discharged from the army partially disabled and was well until 1922. From then until his admission into the clinic, diarrhea had been continuous, and his vitality was low. During these years, an average of from six to eight stools was passed a day. He had lost 15 pounds (6.8 Kg.) in the last two years; his weight on admission was 128 pounds (58.1 Kg.).

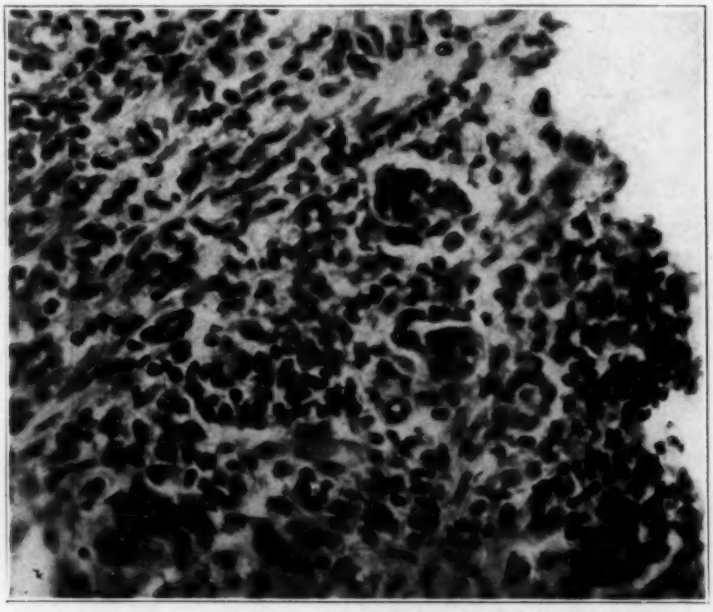

Fig. 3 (case 1).—Same section as that shown in figure 2; × 340.

Pus and blood were found in excess in the stools. Parasites, ova and acid-fast bacilli were not found. The culture yielded the usual diplococcus. On October 2, the hemoglobin was 45 per cent; erythrocytes numbered 3,680,000. The tonsils were septic, and three teeth contained periapical abscesses. Perirectal excoriation, a draining fistula on the right and an anorectal stricture, which barely admitted the index finger, were present. The Wassermann reaction of the blood and the urinalysis were negative. Roentgenograms of the chest, kidneys, ureters and bladder were negative. Roentgenograms of the colon showed narrowing and shortening but no haustra (fig. 4). Proctoscopic examination disclosed a granular ulcerative process, resembling a polyp, and a stricture from 2 to 3 cm. from the anus.

Treatment consisted of a filtrate of the diplococcus, administered subcutaneously, tincture of iodine, 12 minims (0.74 cc.) three times a day, and instillations of witch-hazel daily. The patient improved steadily, and on October 24,

the tonsils were removed. On November 9, the hemoglobin was 74 per cent and the erythrocytes numbered 4,690,000. Proctoscopic examination showed that the condition of the upper part of the rectum and the sigmoid was much improved, only a granular condition remaining. The stricture was about the same. By November 13, rectal bleeding had stopped. From November 23 to December 2, the three teeth showing periapical abscess were removed. Because of the narrowing caused by the stricture, ileostomy was discussed with a surgeon, who decided, however, to delay the operation because of the definite general improvement of the patient. The patient was given a filtrate to use at home, and did well until the middle of January, when the stools became loose and he had frequent cramps as if an obstruction or another perianal fistula had developed. He returned to the clinic, February 4, in an emaciated, exhausted condition. The hemoglobin was

Fig. 4 (case 2).—Roentgenographic appearance of the colon after a barium enema.

40 per cent and the erythrocytes numbered 3,430,000. The urine contained albumin, graded 2. An emergency ileostomy was performed on February 6. The entire colon appeared to be involved. The patient did fairly well for a week, but from then on failed steadily. He died on February 25.

Necropsy showed advanced chronic ulcerative colitis extending into the terminal ileum. Hyperplastic islets of mucosa of a peculiar appearance were disseminated throughout the colon. On microscopic section these proved to be carcinoma, graded 4 (figs. 5 and 6). The periaortic lymph nodes contained carcinoma, and carcinomatous nodules were disseminated over the peritoneum.

Case 3.—A farmer, aged 39, came to the Mayo Clinic in March, 1916. Bloody diarrhea and pain in the left lower quadrant had been present for five years; the

pain was relieved by bowel movement. Two years previously the diarrhea became more severe, and there was more blood and pus; for about six months before admission the pain had been more constant, and the patient had lost 32 pounds (14.2 Kg.). From six to fifteen stools were passed in twenty-four hours. The more he ate the worse the pain became.

After a thorough investigation, a diagnosis of chronic ulcerative colitis was made, and the "Brown operation" and appendectomy were performed. The ileum was severed completely, and the proximal loop only brought out. The patient returned in 1919 much improved, having gained 30 pounds (13.6 Kg.), but he considered the ileostomy opening a nuisance because the prolapse kept him from working. A no. 1 ring pessary was inserted, which seemed to control the prolapse.

Fig. 5 (case 2).—Section of one of the many hyperplastic islets of mucosa disseminated throughout the colon and removed at necropsy; × 75.

In February, 1920, the proctoscopic examination showed a stricture 5 cm. above the anus, so small that the lumen could not be seen. The mucosa showed that the colitis was still active, although the patient was clinically in a fair condition.

The patient secured a job as a taxi driver and supervised his farm. He returned in 1925 in good physical condition, weighing 178 pounds (80.7 Kg.). The stricture in the rectum would not admit the index finger. The ileostomy opening with the aid of the pessary was functioning well. He returned home and was in fair health until about the middle of September, 1927, when the sanguinopurulent rectal discharge increased greatly and at the same time a dull, aching, steady pain

developed at the lower end of the rectum. This became severe in a few days and persisted until his admission to the clinic on December 15. He complained of shooting pains in the genital region, frequency of urination and much difficulty in voiding.

The patient was now 51 years of age. He weighed 158 pounds (71.7 Kg.). The facial appearance was of one in distress. The leukocytes numbered 12,400, and polymorphonuclears, 79 per cent. Proctoscopic examination under regional anesthesia showed the rectal surface to be covered with a grayish, foul-smelling slough, with many irregular areas protruding here and there as far as could be seen. Proctoscopy could not be carried further than 14 cm., because of the limitation of motion and narrowing of the lumen. A specimen of one of the many irregular

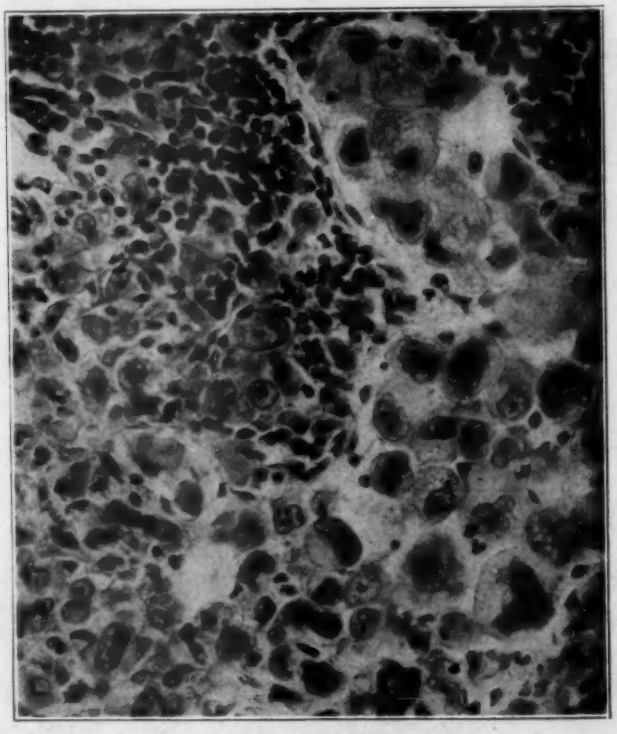

Fig. 6 (case 2).—Same section as that shown in figure 5; × 325.

nodules proved to be adenocarcinoma, graded 3 (figs. 7 and 8). The first phalanx of the index finger was inserted into the rectum, and the mucosa felt rough and stiff. The patient is receiving radium treatment elsewhere.

CASE 4.—A youth, aged 19, first came to the Mayo Clinic on June 28, 1916. He had been passing loose, watery stools containing flecks of blood for nine years. Proctoscopic examination showed granular proctitis. A roentgenogram of the colon was negative. The hemoglobin was 76 per cent. On his return to the clinic on August 21, roentgen-ray examination showed the colon to be thickened and contracted. Achlorhydria was present. From 1916 to 1920, he got along fairly well, with the exception of periods of frequency of urination, the urine containing blood and mucus. In the first ten years of his trouble, he had had several

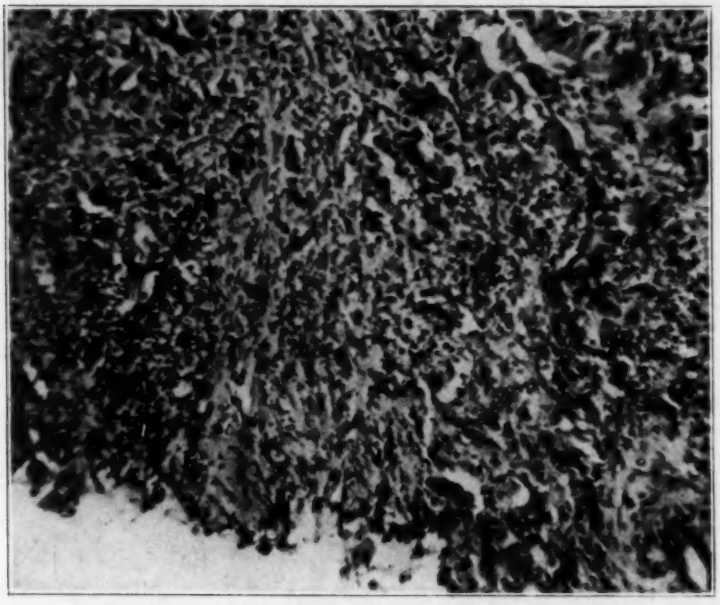

Fig. 7 (case 3).—Section of one of the numerous nodular excrescences of the rectal mucosa removed for diagnosis; × 150.

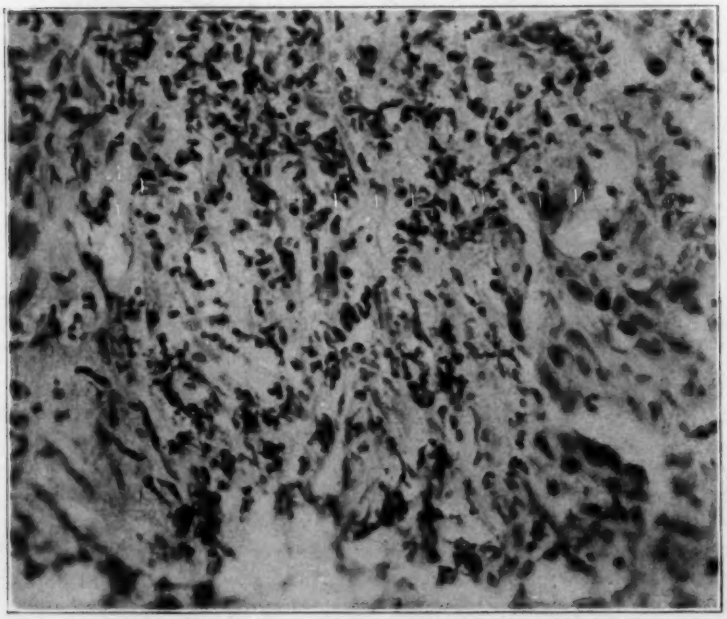

Fig. 8 (case 3).—Same section as that shown in figure 7; × 340.

hemorrhages and became anemic. Intermittent distress at the umbilicus was relieved by bowel movement. He did better on a full diet. In 1920, he had had influenza, after which the condition became somewhat worse. In 1924, the distress increased and bowel movements were more frequent. After a trip south in April, 1927, the urgency and frequency of bowel movements increased, and he went to Battle Creek Sanitarium where he was placed on a vegetable and fruit diet. After this, emetine and stovarsol had been given, but without improvement. In June, the pains became so severe that he "couldn't get his breath." The pain was worse after a bowel movement; morphine was given for relief. On June 24, a hemorrhage from the bowel occurred. His physician wrote to the clinic for some vaccine which was given during August; blood was believed to have disappeared from the stools after this.

Fig. 9 (case 4).—Roentgenographic appearance of the colon in 1927 showing the typical deformity of chronic ulcerative colitis and a definite filling defect in the transverse colon.

At examination, September 7, the hemoglobin was 60 per cent, the erythrocytes numbered 4,600,000, and the leukocytes, 6,100. The chief complaint was that of intermittent severe attacks of pain in the upper part of the abdomen which was relieved by morphine, of which he had as much as 3 grains (0.195 Gm.) daily. Proctoscopic examination showed chronic ulcerative colitis, graded 2. A roentgenogram of the colon after an enema of barium showed ulcerative colitis of the entire colon with a filling defect from a constriction of the transverse colon (fig. 9). The urine showed hyaline casts, graded 4, and pus, graded 1.

On September 9, ileostomy was performed for carcinoma of the transverse colon and metastasis to the pelvis. After a stormy postoperative course, the

patient died on September 20. On this day the blood urea was 252 mg. for each hundred cubic centimeters. Necropsy revealed carcinoma of the transverse colon (figs. 10 and 11), metastasis, chronic ulcerative colitis, generalized peritonitis and multiple infarcts in the lungs. The ulcerative colitis was not active, the mucosa being smooth and shiny, with a suggestion of many healed scars.

CASE 5.—A man, aged 40, came to the Mayo Clinic on Feb. 26, 1923, because of diarrhea of sudden onset two years previously. The rectal discharges averaged from three to fifteen every twenty-four hours. The stools were soft and were mixed with blood and mucus. There was considerable flatulence, and some tenesmus and cramps preceding each bowel movement. The diarrhea was more severe in the afternoon and at night. An acute cold in January had made the diarrhea much worse.

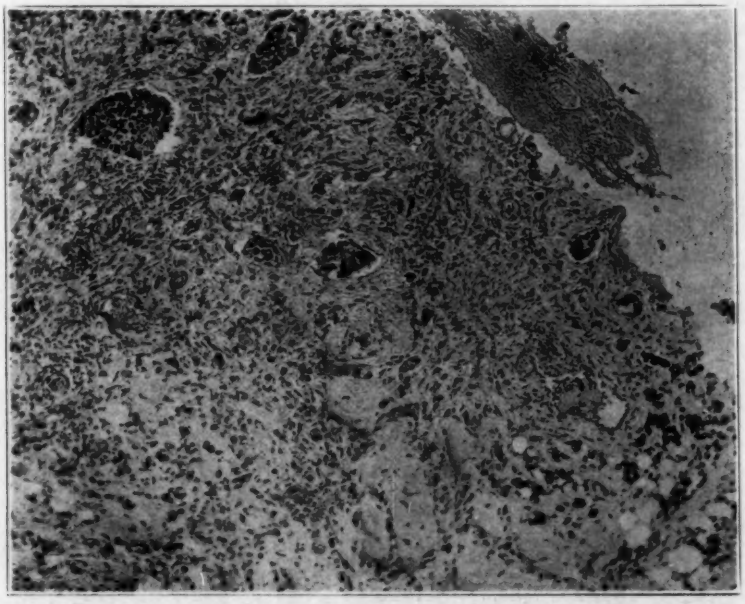

Fig. 10 (case 4).—Section of the tumor which was removed at necropsy and which corresponded to the filling defect shown in the roentgenogram; × 75.

At examination, the Wassermann reaction of the blood and the urinalysis were negative. The leukocytes numbered 10,700. Three teeth with periapical infection and somewhat enlarged tonsils were noted. A roentgenogram of the chest was negative. A roentgenogram showed the colon to be smooth and without haustra. Proctoscopic examination showed rather mild activity in the colon, with greater activity in the sigmoid. Parasites or ova were not found in the stools. A diagnosis of chronic ulcerative colitis was made. Tincture of iodine was given by mouth, and a mild solution of protargin and witch-hazel were given by rectum. On March 26, proctoscopic examination did not show improvement. The patient was dismissed, and the condition of the bowels continued as before until Dec. 20, 1926, when, following the lifting of a heavy grain sack, excruciating pain appeared in the right lower quadrant. This continued for two weeks, during which the patient was disabled. The temperature was taken and found to be between 99

and 101 F. He returned on Jan. 5, 1927. A tender, firm, nodular mass in the right lower quadrant was fairly adherent to the structures around it. Proctoscopic examination at this time showed typical chronic ulcerative colitis, graded 2. The roentgenogram showed that the bowel did not contain haustra, but there was a filling defect in the cecum. The tonsils and infected teeth had not been removed. *Trichomonas hominis* was found in the stools. A culture from the ulcers in the bowel yielded the usual diplococcus. The hemoglobin was 57 per cent, and the leukocytes numbered 12,100. The patient had lost 17 pounds (7.7 Kg.) in a few weeks.

On January 13, ileocolostomy was performed for a cecal tumor which appeared malignant and was surrounded by inflammatory tissue. The adjoining glands were enlarged. Following a fairly uneventful convalescence, four deep exposures of roentgen rays were given as part of the treatment. The patient was dismissed

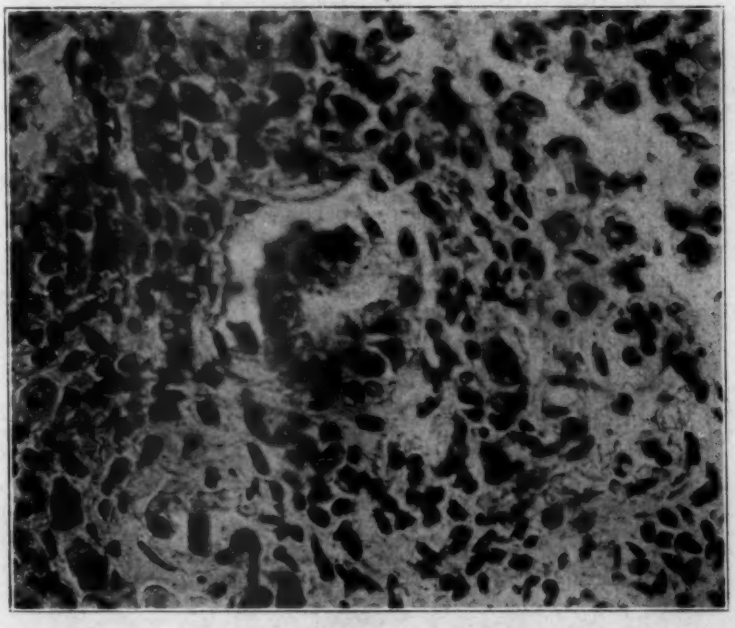

Fig. 11 (case 4).—Same section as that shown in figure 10; × 450.

from observation on February 10, and was instructed to take an autogenous vaccine every five days. The rectal bleeding stopped; the weight increased from 119 to 131 pounds (54 to 59.4 Kg.), and when he returned on March 16, he felt well except for pain in the region of the tumor. On March 18, the ileocecal coil was resected, including the large tumor which the pathologist reported to be ulcerating lymphosarcoma of the cecum, without glandular involvement (figs. 12, 13 and 14). A stormy postoperative course followed; pneumonia developed and later, peritonitis. On March 21, 13 cc. of 1 per cent of mercurochrome-220 soluble was given intravenously; this was repeated two days later. The temperature, which before had remained between 103 and 104.5 F. for several days, fluctuated from 101 to 102 for the next two weeks. Following the injection of the mercurochrome, the bowels became much more active; from ten to thirteen bloody stools were passed

every twenty-four hours. Between April 7 and 11, five deep muscular injections of immune horse serum[12] were given, that is, 10, 15, 15, 15 and 15 cc. were given on successive days. After this, the temperature receded and after April 12 did not go above 99 F. The patient improved gradually and was dismissed on April 17, weighing 113 pounds (51.3 Kg.). He was advised to take the filtrate prepared

Fig. 12 (case 5).—Specimen removed surgically.

from the diplococcus every four or five days, and kaolin if he needed it. At this time he was having from four to six daily bowel movements without blood. On June 6, he had gained 16 pounds (7.3 Kg.), was having three or four daily bowel

12. Rosenow, E. C., and Bargen, J. A.: Unpublished data.

Fig 13 (case 5).—Section of specimen showing in figure 12; × 75.

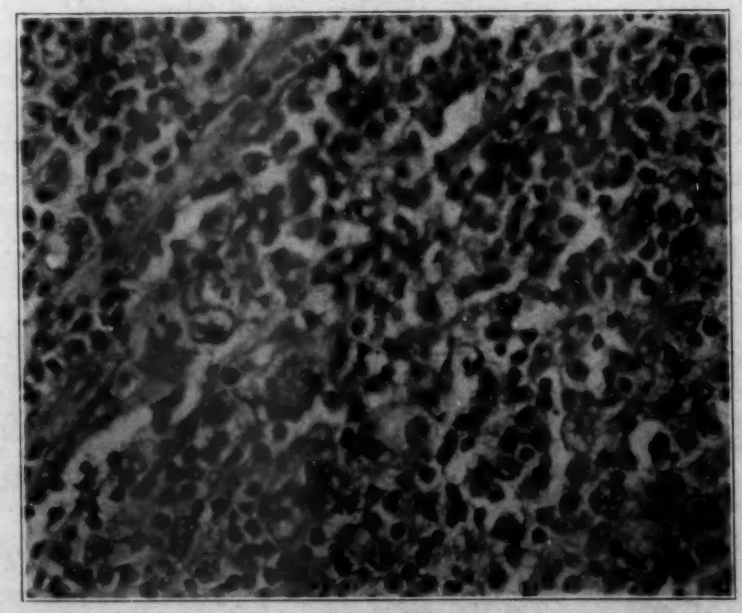

Fig. 14 (case 5).—Same section as that shown in figure 13; × 350.

movements and was feeling well. Roentgen-ray treatment was again administered. He got along well, and then discontinued the vaccine early in September. On October 25, he wrote that he was having a further upset of the bowels, from nine to ten stools without blood being passed daily. A report in March, 1928, stated that he was in good condition.

COMMENT

The paucity of reports in the literature on malignant disease of the colon developing in persons with chronic ulcerative colitis is noteworthy. Struthers [13] emphasized the relationship of chronic ulcerative colitis and polyposis, and suggested that malignant disease may follow these conditions. Hewitt and Howard [14] made similar observations. Wheeler [15] expresses the belief that polyposis occurs as a result of chronic ulcerative colitis. Helmholz [16] called attention to the fact that Virchow and Rokitansky may have described the terminal stage of chronic ulcerative colitis. Soper's [17] work on multiple polyposis of the colon has been illuminating. At the Mayo Clinic the development of polyps has been noted proctoscopically in the course of progressing as well as healing chronic ulcerative colitis. Logan [18] found polyps in 19 of 117 cases. Later, I noted 26 in 200 cases.

In view of the various reports in the literature, the frequency with which polyposis has occurred in the series of cases of chronic ulcerative colitis at the Mayo Clinic and the simultaneous occurrence of polyps and carcinoma in the diseased colon, the following hypothesis is offered: the sequence of events in some cases of malignant disease of the colon is chronic ulcerative colitis, multiple polyposis and malignant disease.

Malignant disease superimposed on chronic ulcerative colitis offers a grave prognosis. Whenever a sudden change for the worse is noted, further proctoscopic and roentgenologic investigations should be made. Operation, even if the malignant condition is discovered fairly early, yields discouraging results. One must then consider medical treatment. The only hope, it seems, is preventive treatment, that is, the cure of the colitis and the removal of the polyps.

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13. Struthers, J. E.: Multiple Polyposis of the Intestinal Tract, Ann. Surg. **72**:649, 1920.

14. Hewitt, J. H., and Howard, W. T.: Chronic Ulcerative Colitis with Polyps: A Consideration of the So-Called Colitis Polyposa (Virchow), Arch. Int. Med. **15**:714 (May) 1915.

15. Wheeler, W. I. de C.: Multiple Polypi of the Colon, Brit. J. Surg. **14**:58, 1926-1927.

16. Helmholz, H. F.: Chronic Ulcerative Colitis in Childhood, Am. Jour. Dis. Child. **26**:418 (Nov.) 1923.

17. Soper, H. W.: Polyposis of the Colon, Am. J. M. Sc. **15**:405, 1916.

18. Logan, A. H.: Chronic Ulcerative Colitis: A Review of 117 Cases, Northwest Med. **18**:1, 1919.

THE BLOOD SUPPLY TO THE APPENDIX*

HARRY KOSTER, M.D.
Attending in Surgery
AND
MORRIS WEINTROB, M.D.
Assistant in Surgery, Crown Heights Hospital
BROOKLYN

This paper is based on the study of the arterial architecture of 100 appendixes, normal and pathologic, removed from human beings representative of the first to the seventh decades of life, inclusive. The method pursued in the study was originally described by Louis Gross in his work on the blood supply to the heart. This consists, in brief, of the injection of the appendicular artery with a barium sulphate-gelatin suspension of known viscosity. The injection is accomplished in an apparatus which permits accurate control and standardization of temperature, pressure and other modifying elements.

The apparatus consists of a wooden box lined with copper and separated into two chambers, an upper and a lower chamber, by a pan which has an outflow tube connecting it with the outside. In the center of the pan are two openings, nicked to prevent dripping into the lower chamber (fig. 1). Outside the incubator is a Wolff flask. Compressed air is forced into this flask until an attached mercury manometer registers 150 mm. of mercury. The pressure tube from this bottle is connected to a large flask containing physiologic sodium chloride solution. The solution is forced out of the flask into a spiral tube in the lower chamber which is immersed in a bath kept warm by an electric immersion heater. The physiologic sodium chloride solution is then conducted into the upper chamber into a small Wolff flask which contains a thermometer. The temperature of the solution is thus accurately determined before it is forced into the blood vessels. By raising or lowering the spiral tube in the water bath, the temperature can be altered to any degree desired, and the sodium chloride solution at the proper temperature is then forced through the appendicular artery until the washings come clear. The entire incubator is kept at a uniform heat by another immersion electric heater, a thermometer being placed in each chamber. Electric bulbs and glass doors render it easy to watch the progress of the injection. When the blood vessels are washed clean, the pressure tube from the manometer bottle is attached to a Wolff

* From the surgical service of the Brownsville and East New York Hospital, Brooklyn.

flask containing the mass for injection which has been kept in the lower chamber. This mass is forced into the vessels until the mercury in the manometer remains constant at 150 mm. without requiring additional compression. The vessel is then tied off, the cannula removed, and the appendix immersed in cold formaldehyde for fixation and bleaching, after which an x-ray picture is made. After fixation, the appendix is gradually dehydrated in alcohol commencing with 50 per cent and changing every alternate day into an alcohol of 10 per cent additional strength until absolute strength is attained. The appendix is then immersed in synthetic oil of wintergreen, and within two days clearing is complete. The finest branches are clearly visible, dissection being rendered simple. The serosa and, separately, the muscularis can be peeled off, and with the aid of an ordinary hand glass, the distribution, direction and anastomosis of even the finest branches are easily studied.

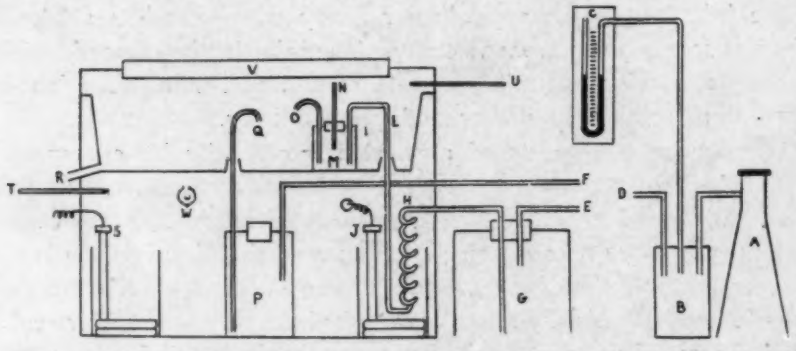

Fig. 1.—Injection apparatus. *A* indicates the compressed air tank which blows air into *B*, the chamber which registers the air pressure by means of manometer *C*. *D* is the pressure tube which can be attached to either *E*, the inlet tube of the physiologic sodium chloride flask, or *F*, the inlet tube of the injection mass bottle. By this means, the sodium chloride solution can be forced out of the flask *G* into the spiral tube *H*, which is being heated by the immersible electric heater, *J*. The sodium chloride solution is thus forced out of the spiral *H* through the tube *L* into the bottle *M*, where the temperature is registered by the thermometer *N*. Tube *O* conducts the sodium chloride solution through the cannulae to the organ. Similarly, by applying pressure tube *D* to *F*, the injection mass can be forced out of bottle *P* through *Q* into the cannula. *R* is the outflow tube; *S*, another immersible electric heater; *T* and *U*, the thermometers for registering the temperature of the chambers; *V*, the glass window for observing the condition of the injecting organ; *W*, an electric illuminating bulb (organ for injection is suspended from a tripod in the upper chamber). (From L. Gross: Blood Supply to the Heart.)

The mass of barium sulphate gelatin is made as follows: Soak 300 Gm. of fine French gelatin (preferably gold label) for two hours in 1,200 cc. of distilled water. To this add 1,000 Gm. of finely powdered

barium sulphate, 500 cc. of distilled water and 2 Gm. of thymol. Heat over a water bath until the gelatin dissolves and the whole mass becomes a homogeneous milky fluid. Filter through two layers of Victoria lawn.

To secure specimens suitable for injection, i. e., the appendix and all of the meso-appendix as far back as the trunk of the appendicular artery before branching begins, the ordinary procedure in the operation of appendectomy had to be modified. The method employed is to pass a suture ligature around the vessel as it enters the base of the meso-appendix on its free border, ligate and then cut free to the base of the appendix. The appendicular base is then ligated and cut distally by the cautery at dull heat. The heat sears the free end, preventing spill, and obviates the undesirable use of a clamp which would injure some part of

Fig. 2.—Normal appendix. Note the secondary branching, tortuosity, encircling branches and the diminution in their size as they approach the free border of the appendix.

the vasculature. The appendix is placed in citrated saline to prevent coagulation in the vessels. A fine glass cannula is then tied into the artery, and the specimen is ready for injection.

CIRCULATION IN THE NORMAL APPENDIX

The appendicular artery arises from the ileocolic artery and enters the base of the meso-appendix at its free border. Usually, this location is marked by the presence of an easily demonstrable gland which, incidentally, is the first to show the presence of an inflammatory lesion in the appendix. This vessel pursues an arcuate course along the free border of the mesentery, approaching the appendix as it extends toward the tip, thus forming with the appendix approximately an isosceles

triangle, the apex of which is the distal appendicular end. In a percentage of cases, the artery instead of terminating at the tip of the appendix rounds the extremity and is continued on the free border of the organ as a "backbone" vessel which extends for a distance of approximately 2 cm. As will be seen later, this "backbone" vessel at this point receives numerous anastomoses.

In its arcuate course, the appendicular artery in the average case gives out seven primary branches. These extend at right angles to the trunk artery and are approximately equidistant and parallel to one another. With the exception of usually the first, all primary branches divide into two encircling branches at a distance of about 5 mm. before reaching

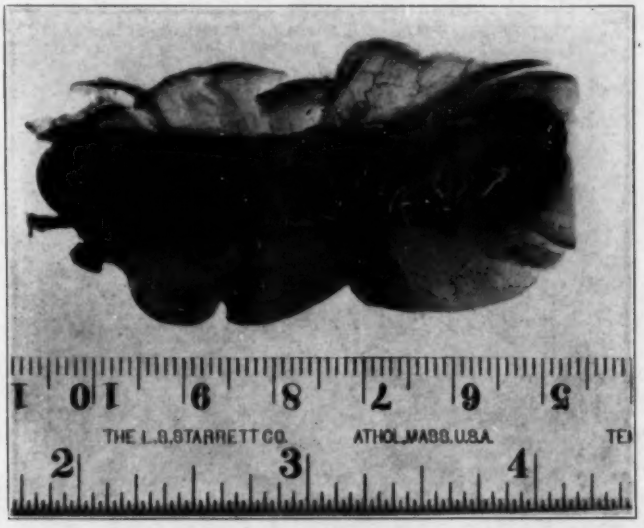

Fig. 3.—Serosa dissected free from underlying coats. Note the fine caliber of the vessels in comparison with the larger vessels of the submucosa.

the appendix. The first primary branch differs in that the secondary branches are given off before encircling branching occurs (fig. 2).

The encircling branches almost immediately break up into two layers, a deep and a superficial, which dichotomize extensively and surround the appendix with tortuous interanastomosing vessels. The superficial layer of vessels runs in the serosa and, much to our surprise, they are of noticeably smaller caliber than those of the deeper layer. The latter distribute themselves in the submucosa. There is apparently no distinct supply to the muscular layers (fig. 3).

Obviously, the caliber of the encircling vessels diminishes as branching proceeds and as the free border is approached. The latter fact

may be of interest in connection with the frequency with which perforations occur at this site.

The description thus far given deals with the vessels of larger caliber. In their distribution, these branches give off a tremendous number of delicate vessels which turn abruptly at right angles to their course, run in a radial direction, and bring about a profuse anastomosis between the branches of the deep and superficial layers. They pass through a hiatus in the musculature, which is readily seen on microscopic section. This system of delicate radial vessels is excellently demonstrated in edematous appendixes, in which the two layers mentioned are more sharply defined and separated.

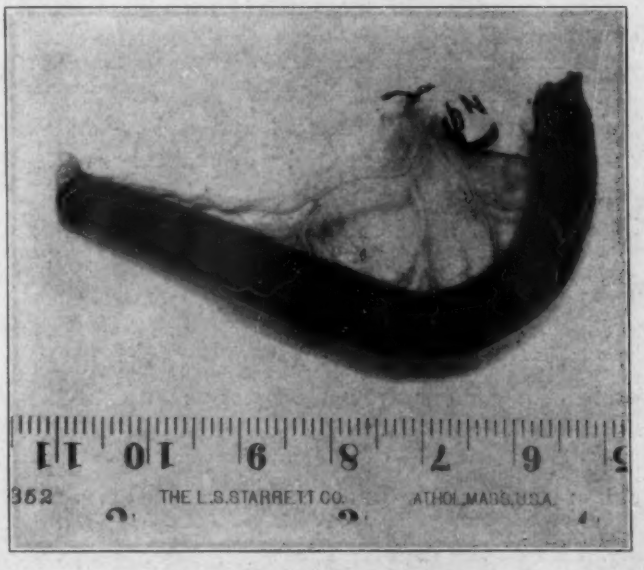

Fig. 4.—Normal appendix. Note the tortuosity of the vessels and the fine vessels in the fat layer, the rami telae adiposae.

The next group of vessels we believe to be of considerable physiologic importance is that system of delicate interlacing and interanastomosing vessels found in the fat of the meso-appendix. These fine vessels (rami telae adiposae) arise from the appendicular artery as well as from its branches in the meso-appendix, interanastomose freely in the fat of the meso-appendix and, as in other organs in which these vessels are found, e. g., the heart, kidney and other organs, often accompany larger branches. As will be noted in the subsequent description of the circulation of the pathologic appendix, these fine vessels apparently play an important rôle in compensating for obliterated or thrombosed vessels (fig. 4).

Microscopic study results in the confirmation of many of these gross observations. It is apparent that there is a much larger and a much more profuse vascular supply to the submucosa than there is to the serosa. Examination of serial sections in the process of the construction of a wax model for the more accurate study of the arterial tree confirmed the belief that a distinct blood supply peculiar to the muscularis is absent. Where blood vessels are seen in the muscularis they are small, right angled, connecting vessels which span the gap between the superficial serosal and the deep submucosal layers and in so doing pass through a "defect" in the musculature, the so-called hiatus-muscularis. From the large vessels in the submucosal layer, fine vessels run toward the mucosa. These vessels are quickly lost sight of as they reach the mucosa. On the whole, the formed vascular supply in the area of the lymph follicles is scant. The follicles are, however, generously supplied with lymphatic vessels. It would seem from this distribution as though the absorption from the lumen of the appendix would be primarily and mainly by way of the lymphatics rather than directly into the blood stream—unlike the arrangement in the jejunum and ileum (fig. 5).

CIRCULATION IN THE PATHOLOGIC APPENDIX

The pathologic appendixes which we have examined resolve themselves into four groups: (*a*) early exudative appendixes, in which gross evidence of inflammation is not striking; (*b*) marked exudative appendixes, in which though the tissue layers do not as yet show macroscopic evidence of necrosis, definite, easily demonstrable evidence of acute inflammation is seen; (*c*) well marked suppurative hemorrhagic and necrotic appendixes in which the necrotic lesion has not, however, led to extensive gangrene, and (*d*) gangrenous appendixes in which considerable portions of the organ are seats of ischemic necrosis.

The changes in the vascular picture which accompany the various phases in the transition from normalcy through the grades outlined in the foregoing paragraph (obviously artificially and arbitrarily outlined) parallel closely the general pathologic condition of the organ. Thus, one finds appendixes belonging to category (*a*) which show scarcely any macroscopic deviation from the normal in their blood supply.

One of the earliest visible changes in the arterial tree is a diminution in the tortuosity of the larger branches in the two layers (deep and superficial). Usually concomitant with this, and often apparently in direct proportion to the extent of this diminution, is an increased prominence of the rami telae adiposae. As the organ becomes more swollen and the inflammatory lesion more marked, the larger branches completely lose their tortuosity; at the same time, the radial vessels communicating between the two layers become increasingly prominent. The

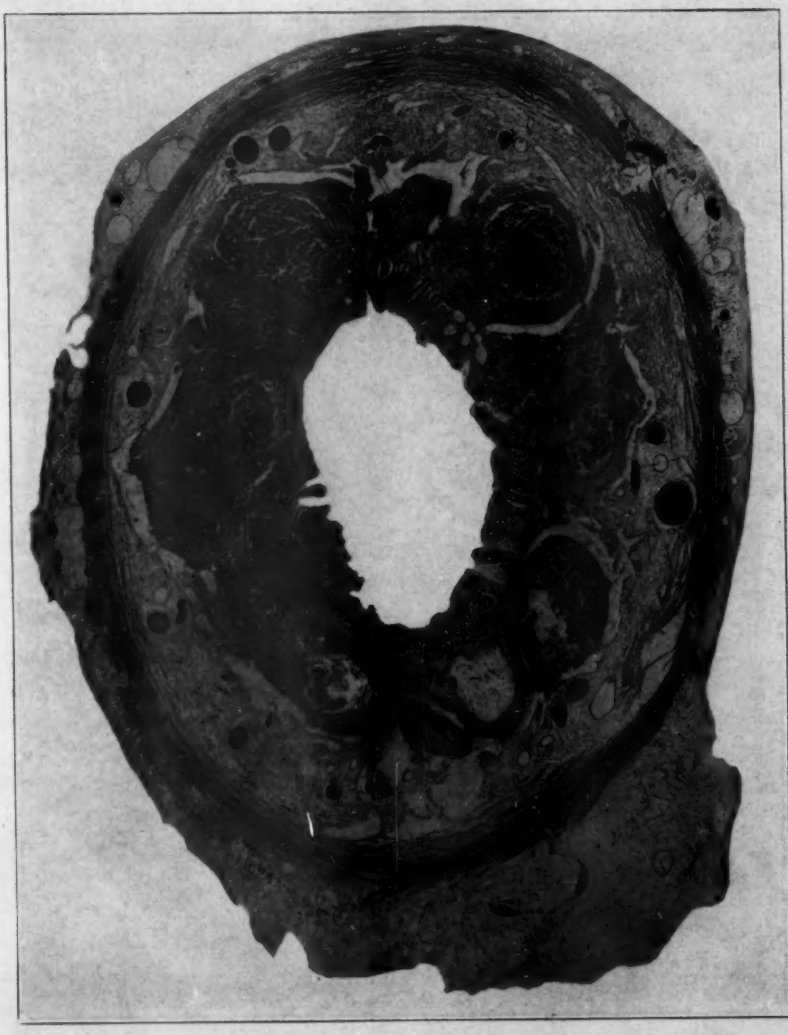

Fig. 5.—Microscopic section of a normal appendix. The dark, ovoid areas are cross-sections of the injected vessels. Note the difference in size and profusion of the vessels in the submucosa as compared with these in the serosa, and the relative paucity of formed vessels in the mucosa. The vessels seen in the muscular layer merely traverse it, as shown by serial sections.

relation between the inflammatory edema, on the one hand, and the diminished tortuosity and increased prominence of the radial communicating vessels, on the other, is so definite that the microscopic picture of edema and inflammation can be accurately predicted from the gross examination of the vessels in the cleared appendix (fig. 6).

Following this stage, one of the most conspicuous additional changes consists in the abrupt termination of the lumen of the vessels, often at points where the caliber has not yet appreciably diminished, that is, at considerable distance from their estimated ultimate distribution. This marks the transition to the development of gangrene in the tissue (fig. 7).

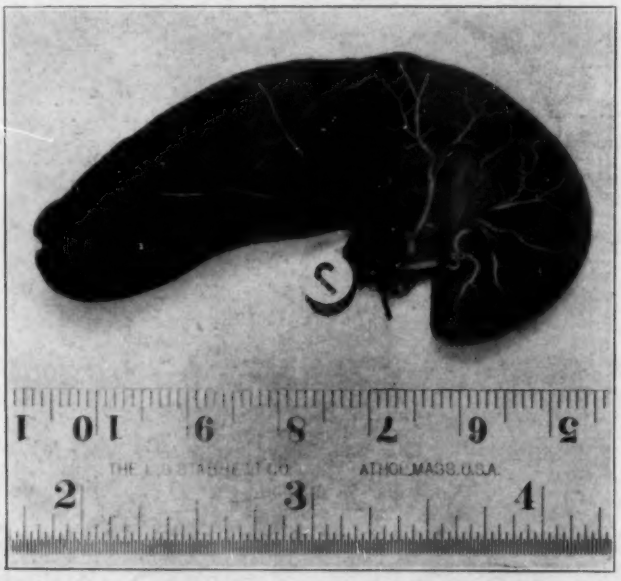

Fig. 6.—Acute suppurative appendicitis. Note the diminution in tortuosity and the greater prominence of the vessels.

Finally, in the specimens representative of category (*d*) is seen complete absence of blood supply to the affected portions. It is of interest to note that when these ischemic areas involve only part of the entire organ, they are most frequently seen at either the proximal or the terminal portion of the appendix, usually the latter. We have not yet encountered ischemic necrosis involving only the middle portion of the appendix.

Microscopic study confirms the gross observations. In the early exudative cases, the only vascular changes noted are increased prominence of the capillaries and apparent distention of the larger vessels.

In the appendixes of category (*b*), and more particularly in (*c*), the rami telae adiposi are prominent, and it seems logical to conclude that their increased size is probably a compensatory and defensive phenomenon.

As the edema increases, not only do the vessels straighten out, but, as a result of the surrounding compression, their caliber diminishes until ultimately (with marked edema) the lumen does not remain patent. Gangrene naturally ensues. The abrupt termination of the lumen of the vessels, often at a point where the caliber has not yet appreciably diminished as previously mentioned, is not always due to the com-

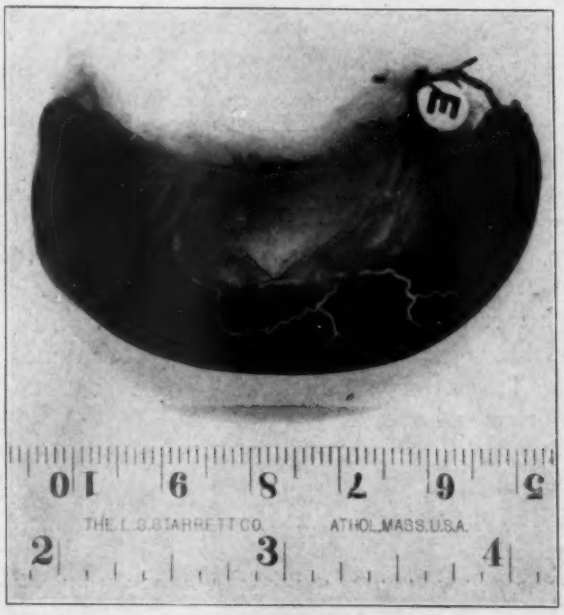

Fig. 7.—Gangrenous appendicitis. Note the abrupt termination of the large blood vessels distal to which is the area of gangrene. The diminution in tortuosity is quite evident. This photograph shows clearly the increased prominence of the rami telae adiposae (*B*).

pression of edema; in some instances, the vessels (distal to the abrupt termination of the injected mass) were found to contain thrombi. Thus, gangrene may result from compression outside the vessels or from occlusion within.

COMMENT

The macroscopic observations on the blood supply to the normal appendix show that the appendicular arterial tree is remarkably constant in its architecture.

The definite determination of the supply into two layers, the richer of which is the deeper, and the absence of a distinct blood supply to the mucosa, are undoubtedly of physiologic importance. Attention is again drawn to the remarkable corkscrew and spiral character of the appendicular branches of the second, third and subsequent orders. From analogy with other organs in which this type of vessel is found, e. g., the uterus, intestine, urinary bladder, etc., this tortuosity speaks for a structure which is constantly changing in shape and in caliber.

The next striking point about the blood supply is its richness and profuse anastomosis. This, again, is analogous to the condition found in organs subject to vascular obliteration, e. g., the heart. The number of fat vessels found in the meso-appendix seems to be out of proportion to that necessary to nourish a similar amount of fat, and the close parallelism between the prominence of these vessels and the extent of the inflammatory process in the appendix suggests that these vessels play a compensatory rôle.

It has been shown that inflammations of the appendix are consistently paralleled by changes in the course and character of the blood vessels. Undoubtedly, most of these changes follow the original inflammatory changes and are due to the edema. Another study is under way to determine whether a primary vascular lesion, such as, for example, a bacterial embolus, may not be responsible for at least some of the lesions found in the diseased appendix, and perhaps at times be causally responsible for appendicitis.

The diminution in tortuosity and the increased prominence of the radial twigs are undoubtedly occasioned by the swelling of the appendix and separation of the layers. Vascular obliteration is due to edema and in some instances to thrombi.

It is obvious that at least in those cases coming under categories (*a*) and (*b*) in which the vascular changes are only qualitative in nature, restitution to integrity of the organ may follow a subsidence of the inflammation. When, however, the process has proceeded to vascular obliteration to any considerable extent, complete return to normalcy is hardly to be expected.

There remains to be explained the peculiar fact that the middle portion of the appendix is rarely involved alone in an ischemic gangrenous lesion. A satisfactory explanation for this phenomenon has not as yet been found.

SPONTANEOUS DISLOCATIONS OF THE HIP JOINT DURING EARLY LIFE

REPORT OF TWENTY-EIGHT CASES*

VERNON L. HART, M.D.
ANN ARBOR, MICH.

Dislocation of the hip joint may be classified as congenital, acquired traumatic and acquired nontraumatic, which is also termed pathologic or spontaneous. From November, 1923, to May, 1928, 103 patients with congenital dislocations of the hip joint, six with traumatic and twenty-eight with spontaneous dislocations have been admitted to the University Hospital. Numerous articles have appeared in the literature concerning congenital and traumatic dislocations; however, comparatively little space has been given to the discussion of spontaneous dislocation of the hip joint, which is undoubtedly more frequent than traumatic dislocation, congenital dislocation being the most frequent type. The incidence of traumatic dislocation would obviously be greater in an industrial center; in general, it is not a common form of injury. Wilson and Cochran [1] state that "traumatic dislocation of the hip joint is an uncommon accident and forms only about 2 per cent of all dislocations. Because the exposure to trauma is greater, it occurs more frequently in males than in females, and usually between the ages of 15 and 50 years." Spontaneous dislocation appears to affect males and females about equally, and usually occurs during the age periods of infancy, childhood and early adolescence. Of the twenty-eight cases included in this report, fourteen occurred in males and fourteen in females, and in all the cases the dislocation occurred before the age of 17 years. There is no record in the university Hospital of a spontaneous dislocation of the hip joint occurring during the age periods of late adolescence, early or late adult life.

ETIOLOGY

Metastatic septic arthritis of the hip joint, secondary to a remote infection, occurred in sixteen of the twenty-eight cases. Five patients gave a history of infection of the upper respiratory tract, diagnosed as "grip" or "influenza," preceding the involvement of the hip joint. Acute osteomyelitis, with subsequent infection of the hip joint, occurred in three patients. A history of a "discharging ear" soon followed by a

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* From the Orthopedic Division of the Department of Surgery, University Hospital.

1. Wilson, P. D., and Cochrane, W. A.: Fractures and Dislocations, Philadelphia, J. B. Lippincott & Company, 1925, p. 457.

painful hip was presented by two patients. Pneumonia with empyema, tonsillectomy complicated by aspiration pneumonia and empyema, scarlet fever, acute rheumatic fever, suppurative axillary adenitis and wound infection of the face were the remote sources of infection in the remaining six cases. Cultures of pus obtained from eight of the sixteen patients demonstrated the presence of the following causative agents: *Staphylococcus aureus,* four; *Streptococcus hemolyticus,* two; *Staphylococcus albus,* one; *tubercle bacillus,* two, and *Diplococcus pneumoniae,* one.

The source of the pus in the foregoing cases was from the hip joint, except in two patients. The patient in case 14 developed a metastatic purulent arthritis of the elbow, from which the pus was obtained; in case 12 the pus was obtained from the pleural cavity.

TABLE 1.—*Classification of Cases*

1. Acute septic arthritis of the hip joint secondary to		
Acute rheumatic fever	1	
Infection of the upper respiratory tract	5	
Scarlet fever	1	
Otitis media	2	
Tonsillectomy (aspiration pneumonia)	1	
Acute osteomyelitis	3	
Pneumonia	1	
Suppurative axillary adenitis	1	
Wound infection of face	1	
		16
2. Anterior poliomyelitis	4	
3. Congenital spastic paralysis	4	
4. Chronic infectious arthritis		
a. Polyarticular arthritis (Still's disease)	2	
b. Tuberculous arthritis	2	
		12
		28

Four patients presented a dislocation of the hip joint resulting from paralyses of anterior poliomyelitis involving the muscles surrounding the hip joint. Not only did the residual paralyses involve the muscles controlling the hip joint, but there were extensive paralyses involving both lower extremities in three patients, and marked involvement of the dislocated extremity in the fourth patient. The local paralyses about the hip joint are, as a rule, associated with paralyses disturbing stability and mobility of the knee and foot; also abdominal paralyses with resulting spinal curvature and paralyses of the muscles of the upper extremities may be present. Many of the associated deformities are even more serious lesions than the dislocation, obviously, making the campaign of treatment a complicated problem in certain individual cases. In each of the four patients, the head of the femur could easily be displaced and reduced in the acetabulum by manipulation. Sever [2] reserved the

2. Sever, J. W.: Boston M. & S. J. **165**:313, 1911.

term subluxation for this type and dislocation when the femoral head lies habitually outside of the acetabulum.

An analysis of the function of the muscles surrounding the dislocated hip in the four patients is given in table 2.

A study of the localized paralyses about the dislocated hip joint shows that the extensor, or gluteus maximus muscle, and the abductor muscles, principally the gluteus medius, were either completely or extensively paralyzed, while the flexor and adductor groups were either normal or only slightly involved. It is a physiologic phenomenon that normal unopposed muscle fibers shorten and if maintained in this position will undergo actual structural shortening, resulting in contractures. Without treatment the unopposed flexors and adductors tend to shorten, producing a flexion adduction contracture of the hip joint, which position is productive of dislocation. Each of the four patients presented the flexion adduction contracture deformity of the involved hip.

TABLE 2.—*Function of Hip Muscles*

	Flexors	Extensors	Abductors	Adductors	Tensor Fascia Lata
Case 17	Good	Poor	Poor	Good	Good
Case 18	Good	Zero	Zero	Normal	Normal
Case 19	Normal	Zero	Zero	Good	Fair
Case 20	Record not accurate due to lack of cooperation				

Congenital cerebral paralysis with paraplegia was the etiologic factor in four patients. Loss of muscle coordination, with the resulting deformities of adduction of the hip joints, shortening of the hamstring groups of muscles and talipes equinus forms the usual clinical picture in cases of congenital cerebral paralysis with spastic paraplegia. A large group of patients with spastic paraplegia with the foregoing deformities were admitted to the hospital; however, only four developed posterior dislocation of the hip joint. An analysis of the position of the dislocated extremity revealed a flexion internal rotation position, associated with the adduction. Flexion contracture of the hip joint is a frequent occurrence with residual paralyses of anterior poliomyelitis, involving the muscles surrounding the hip joint, without the production of dislocation. However, when adduction and internal rotation are combined with the flexion contracture, dislocation may occur.

Two children were admitted to the hospital with posterior dislocation of the hip joint, complicating polyarticular arthritis or Still's disease. Neither child had been ambulatory during the six years previous to the time of admission. There were numerous joints involved and many associated deformities, which required correction preliminary to any treatment for reduction of the dislocation of the hip joint.

Flexion deformities of the hips frequently result during the course of chronic infectious arthritis without the development of dislocation, but if adduction and internal rotation are added to the flexion deformity of the hip joint, dislocation may result. The combination of flexion, adduction and internal rotation may be present without the production of dislocation. Undoubtedly this is due to the insidious onset with the formation of intra-articular and extra-articular adhesions and fibrosis, which aid in maintaining the femoral head in the acetabulum. The dislocated hip in each of the two children was in a position of flexion adduction and internal rotation.

Fig. 1 (case 1).—Spontaneous dislocation of the left hip secondary to acute rheumatic fever.

A positive diagnosis of tuberculosis of the hip joint with posterior dislocation was made in two patients. The attitude of flexion adduction and internal rotation is the usual one in late untreated cases of tuberculosis of the hip joint. Dislocation is unusual, perhaps also due to the insidious onset of the disease and scar formation about the femoral head aiding in the prevention of dislocation. During the acute stage of tuberculous arthritis with muscle spasm, the position of flexion, abduction and external rotation is the rule.

If it is replaced by flexion, adduction and internal rotation, before the formation of considerable fibrosis, then dislocation is imminent. The dislocated extremity in each of the two children was held in the position of flexion adduction and internal rotation.

AGE INCIDENCE

The dislocation of the femoral head from the acetabulum occurred in each of the twenty-eight cases before the age of 17 years. Spontaneous dislocation of the hip joint may undoubtedly occur during adult life, although there is no record in the University Hospital of its

Fig. 2 (case 1).—Roentgenogram after preliminary skeletal traction and arthrodesis of the left hip joint. The result is most satisfactory. There is at present a bony ankylosis of the left hip joint in a good position for weight bearing.

occurrence. Hilton [3] recognized that dislocation complicating hip joint disease is usually a condition of early life. He stated that "the acetabulum in a child is very shallow compared with that of an adult. It thus offers greater facility for displacement. This, I apprehend, may be the reason why dislocation of the thigh bone occurs so frequently in cases of hip joint disease at an early period of life."

3. Hilton, J.: Rest and Pain, New York, 1879, p. 192.

HIP INVOLVED

Of the twenty-eight cases reported in this paper, three presented bilateral and twenty-five unilateral dislocation of the femoral head from the acetabulum. The unilateral dislocations involved the left hip in sixteen cases and the right hip in nine cases. Twelve of the twenty-five patients had some existing pathologic condition in the hip joint or surrounding groups of muscles of the opposite extremity. In each of the twenty-eight patients, the dislocated extremity was in a position of

Fig. 3 (case 10).—Osteomyelitis of the greater trochanter, femoral neck and upper femoral shaft. Note the position of instability and threatening dislocation of the left femoral head from the acetabulum. The relation between the position of instability and dislocation of the femoral head was not recognized in this case. The position of instability was not changed to the position of stability, and spontaneous dislocation resulted. See figure 4.

flexion adduction and internal rotation, except in case 7, in which the patient entered the hospital with a purulent arthritis of the left hip joint, complicated by dislocation, with an attitude of flexion abduction and external rotation. At operation, the capsule of the hip joint was found to be under marked tension and greatly thinned, due to the pressure of an intracapsular abscess. The pressure of the abscess,

with gradual stretching and thinning of the capsule, forced the femoral head from the acetabulum although the extremity was held in the position of stability.

PATHOLOGY

The local pathologic condition of the hip joint varied, depending on the etiologic factor, age of the disease and the period of weight bearing. The pathologic changes of the first group of sixteen patients with septic arthritis of the hip joint varied from a serous to a purulent arthritis with or without destruction of bone and soft tissue.

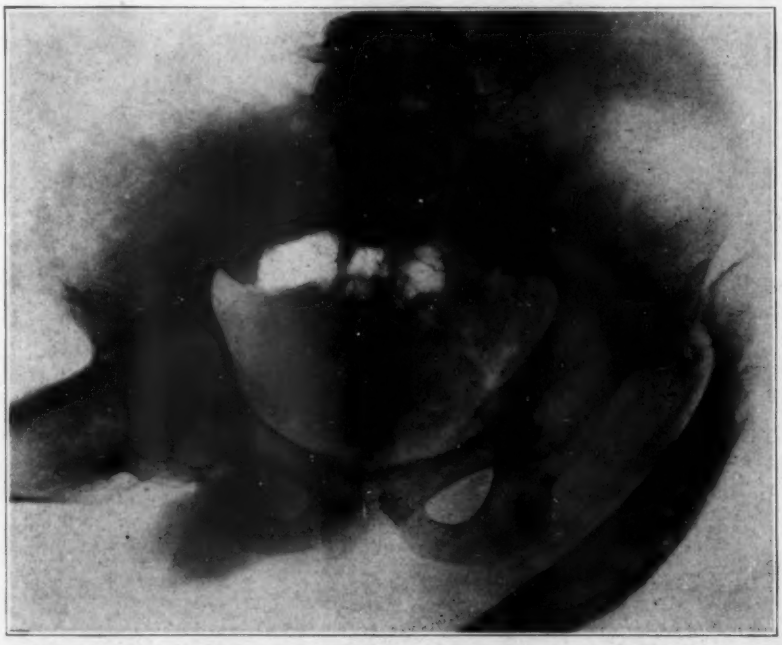

Fig. 4 (case 10).—The position of instability was not corrected to the position of stability, and spontaneous dislocation resulted.

In each case the normal muscle balance of the surrounding groups of muscles was disturbed owing to muscle spasm during the acute stage of the disease. The second and third groups of patients with involvement of the lower and upper neurone, respectively, obviously did not present any arthritic changes. The local pathologic condition consisted in a disturbance of the normal muscular balance, resulting from flaccid paralyses of anterior poliomyelitis and muscle incoordination with increased muscle tone as the result of a cerebral lesion. The local pathologic condition in group 4 likewise varied from slight to extensive bone and joint destruction with a disturbance of the normal muscle balance, due to muscle spasm present during the acute period of the

disease. It is clear that a derangement in the muscle balance is the one pathologic factor common to all cases and should be considered the essential factor in the mechanism of the development of the dislocation.

MECHANISM OF DISLOCATION

In a recent paper, R. Watson Jones [4] of Liverpool, clearly demonstrated that the mechanism of the production of the dislocation is a derangement of the normal action of the muscles surrounding the hip joint and is not dependent on lesions of bone or ligament. The normal

Fig. 5 (case 5).—Tonsillectomy complicated with aspiration pneumonia, metastatic septic arthritis of either hip joint with bilateral spontaneous dislocation and bilateral epiphyseal separation. During the early stage of involvement of the hip joint, the extremities were supported with pillows beneath the knees, placing hips in position of instability.

muscular arrangement about the hip joint may be altered by muscle spasm, muscle paralyses and muscle incoordination. Muscle spasm is always present during the acute phase of hip joint infection, and without treatment the extremity assumes an attitude of flexion, associated with either abduction and external rotation or adduction and internal rotation. One has observed that the most frequent position assumed during the acute stage of hip joint infection is flexion, abduc-

tion and external rotation, without the production of dislocation. The position of flexion adduction and internal rotation is not infrequent, and it is this group in which dislocation is imminent. The first position is one of stability; the second is one of instability. Regarding the second position, Jones [4] states that "in this position the head of the femur is only partly covered by the postero-inferior rim of the acetabulum—its shallowest rim, so that there is little bony

Fig. 6 (case 5).—Roentgenogram following incision and drainage of abscesses and an attempt to place the extremities in the physiologic position by skin traction. Both sequestrated epiphyses were excised.

obstacle to dislocation. The greater part of the head is in contact with the capsular ligament, which is also comparatively weak at this part (ischiocapsular fibres)." Eleven of the twenty patients included in groups 1 and 4 had bilateral involvement of the hip joint. The extremity in a position of flexion abduction and external rotation was

4. Jones, R. W.: Brit. J. Surg. **14**:36, 1926.

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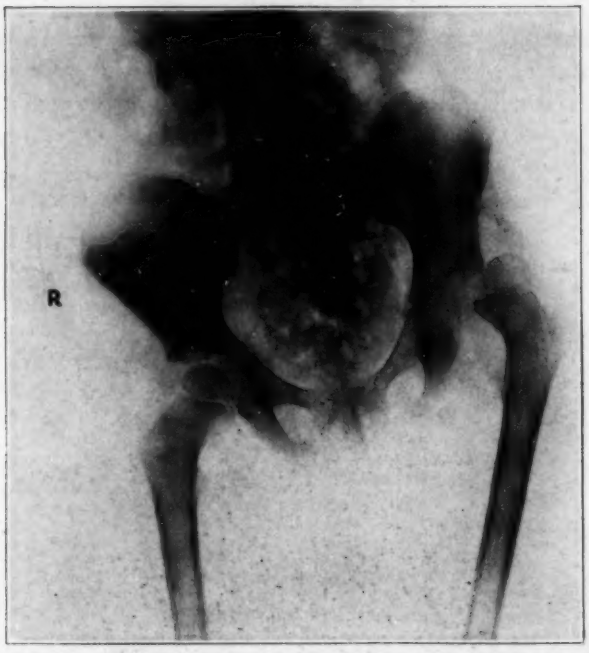

Fig. 7 (case 4).—Suppurative axillary adenitis with metastatic septic arthritis of the left hip joint. Note the position of instability and resulting spontaneous dislocation of the left hip.

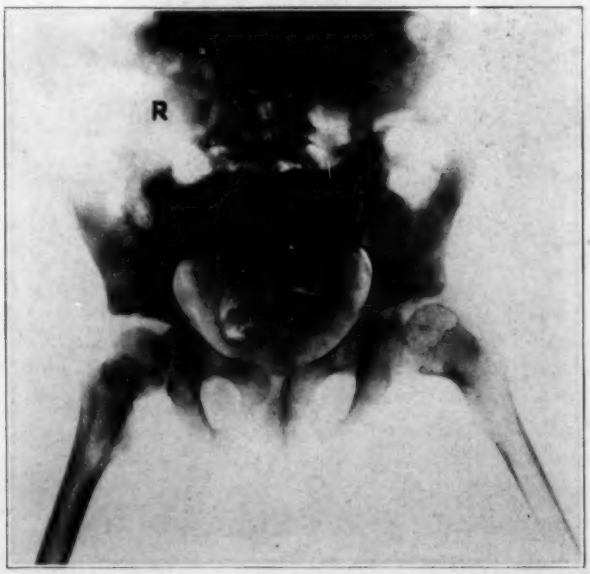

Fig. 8 (case 4).—Complete reduction of the femoral head in the acetabulum following skin traction, gradually changing the position of instability to that of stability—abduction and extension.

in no instance associated with dislocation; the dislocation in the eleven cases was on the side which assumed the attitude of flexion adduction and internal rotation. It is of interest to note the frequency of bilateral involvement of the hip joint in the infectious groups. Figure 15 demonstrates the attitude of flexion abduction and external rotation assumed by the patient at the time of admission to the hospital with an acute septic arthritis of the right hip. One notes that the normal extremity was held in a position of flexion adduction and internal rotation—an instinctive effort on the part of the patient to support and splint

Fig. 9 (case 17).—Residual paralyses of anterior poliomyelitis involving muscles of the right hip joint with resulting spontaneous dislocation.

the involved extremity for the purpose of relieving muscle spasm and pain. The patient complained of pain in both hip joints, The added strain to the normal hip may have caused its lowered resistance, permitting the infection to localize in the joint, with a resulting bilateral infection of the hip joint with one hip in the position of stability and the opposite hip in the position of instability, thus favoring dislocation. It is clear that the muscle spasm should be relieved by means of skin traction and not by support offered by the patient's normal extremity.

The group of patients with residual paralyses of anterior poliomyelitis presented a derangement of the action of the muscles controlling

the dislocated hip. In each case the position of instability was present due to the development of contractures of the stronger unopposed flexor and adductor muscle groups.

The disturbance of the normal muscle function in group 3, congenital spastic paralysis, was essentially a result of loss of normal muscle coordination, the stronger flexor, adductor and internal rotator groups of muscles forcing the hip joint into the position of instability with resulting dislocation.

Fig. 10 (case 17).—Note reduction of the femoral head in acetabulum. Dislocation and reduction can be accomplished with ease by manipulation without anesthesia.

DIAGNOSIS

The clinical signs and symptoms are similar to those present in congenital dislocation. There is a definite limp and lordosis when walking, due to true shortening and posterior displacement of the femoral head in relation to the normal weight bearing line, respectively. A positive Trendelenburg sign may be present due to a disturbance of the integrity of the gluteus medius muscle. Actual and apparent shortening are present on comparative measurements,—the amount of true shortening

depending on the degree of displacement upward and the period of time that the stimulus of normal function has been lost. The involved extremity is held in an attitude of flexion adduction and internal rotation with limitation of the opposite movements. There is an abnormal depression of Scarpa's triangle with the head of the femur displaced posteriorly out of the acetabulum. The greater trochanter is above Nelaton's line due to the upward displacement of the femoral head. Telescoping of the

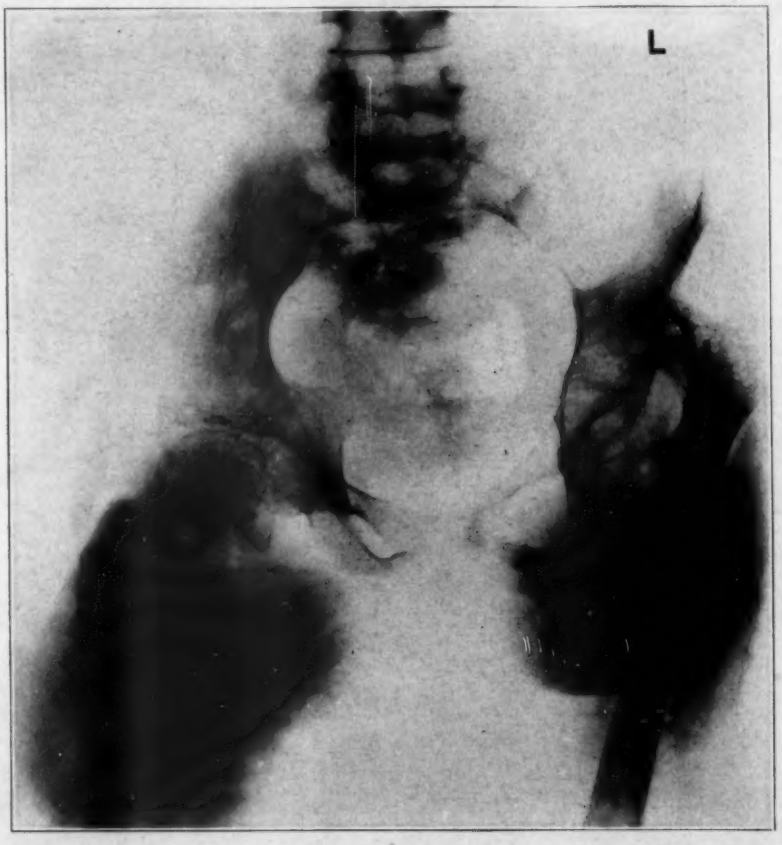

Fig. 11 (case 25).—Polyarticular arthritis, "Still's disease," with spontaneous dislocation of left hip. Note the position of instability of the dislocated hip and the position of stability of the opposite nondislocated hip.

femoral head on manipulation with the pelvis fixed entirely depends on the local pathologic condition. With relaxation of the capsule and absence of fibrosis, there may be marked telescoping; however, the head of the femur may be absolutely fixed due to a fibrous or bony ankylosis of the femoral head to the ilium. The head of the femur is displaced posteriorly and may be palpated in the gluteal region on the dorsum of

the ilium. The presence of signs of infection, muscle spasm, muscle paralyses and muscle incoordination depends entirely on the primary etiologic factor.

DIFFERENTIAL DIAGNOSIS

The diagnosis of the dislocation as a rule is not difficult, although one may be confused by certain observations. Patient A. R., with residual paralyses of anterior poliomyelitis, with involvement of the hip muscles, presented an habitual posterior and upward dislocation of the

Fig. 12.—Photograph of patient in case 25, figure 11. Note the shortening of the left dislocated extremity held in the position of instability.

femoral head with contractures of the flexor and adductor muscle groups. The onset of anterior poliomyelitis occurred when the patient was 10 years of age, and the mother said that the child had limped since the period of infancy. The dislocation was undoubtedly congenital. Patient F. R. entered the clinic at the age of 14 years with the same clinical signs (fig. 16). The onset of the infantile paralysis was before the patient had started to walk. It could not be stated definitely whether the dislocation was congenital or acquired. Patient S. R. was unable to walk because of the development of a marked flexion adduction and

internal rotation deformity of the right hip. Examination revealed residual paralyses of anterior poliomyelitis involving the muscles controlling the hip joint. The head of the femur was easily palpated in the gluteal region; however, a roentgenogram demonstrated that the femoral head was not dislocated. In this instance, the femoral head was easily palpated posteriorly because of the marked atrophy of the gluteus maximus muscle. Patient S. R. entered the clinic with a suppurative arthritis of the left hip with the involved extremity in the position of instability (fig. 18). There was true shortening, and the greater

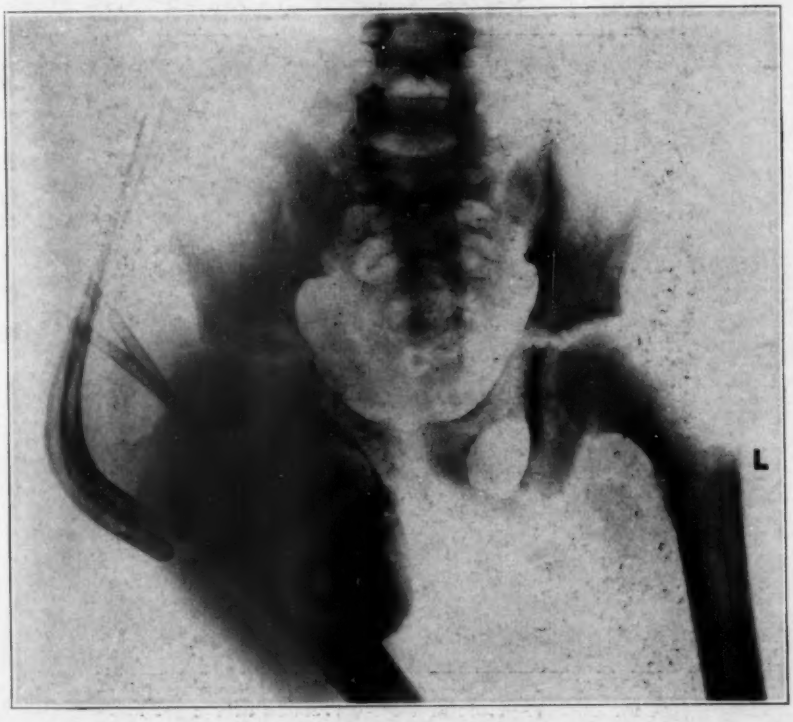

Fig. 13 (patient H. P.).—Postoperative osteomyelitis of the ischium and greater trochanter. The position of instability resulted from muscle spasm. Note the threatening dislocation of the femoral head from the acetabulum. Dislocation was prevented by the application of skin traction with the extremity in position of abduction and extension. See figure 14.

trochanter was above Nelaton's line. A roentgenogram revealed that the femoral head had not been dislocated from the acetabulum, but a separation of the upper femoral epiphysis with a posterior and upward displacement of the femoral neck had occurred. A woman, G. B., developed a suppurative arthritis of the hip joint following parturition (fig. 17). The involved extremity was held in the position of instability.

There was true shortening, and the greater trochanter was above Nelaton's line. Palpation of bony landmarks was not possible because of the inflammatory reaction. The roentgenogram revealed a fracture of the neck of the femur without dislocation.

TREATMENT

I believe that spontaneous dislocation of the hip joint may be considered a preventable condition, and emphasis should be placed on the preventive treatment, because when the deformity is once established, any attempt at correction requires a long period of hospitalization, and

Fig. 14 (patient H. P.).—Note that the correction of the position of instability by skin traction prevented dislocation of the femoral head from the acetabulum.

treatment does not always offer satisfactory correction of the disability. An appreciation of the mechanism of the development of the dislocation should enable one to apply the necessary mechanical apparatus preventing the patient from assuming the position of instability, which is responsible for the dislocation. During the acute stage of any infectious process involving the hip joint, the muscle spasm may be relieved by the application of skin traction and the extremity placed in extension and abduction, which is the position of stability. This method not only relieves muscle spasm and guards against dislocation, but also prevents the patient from utilizing the normal extremity for instinctive traction,

which places the uninvolved hip in the position of instability and favors bilateral involvement of the hip joint. Following the relief of muscle spasm, the skin traction may be continued for the purpose of partial immobilization of the hip joint, if motion is desired. If one anticipates bony ankylosis, a solid plaster hip spica may be applied in the optimum position for ankylosis of the hip joint. From experience I consider the optimum position for ankylosis to be neutral as regards abduction and adduction and neutral as to rotation and the position of flexion entirely dependent on the occupation of the individual. In children, the hip joint is placed in about 20 degrees flexion.

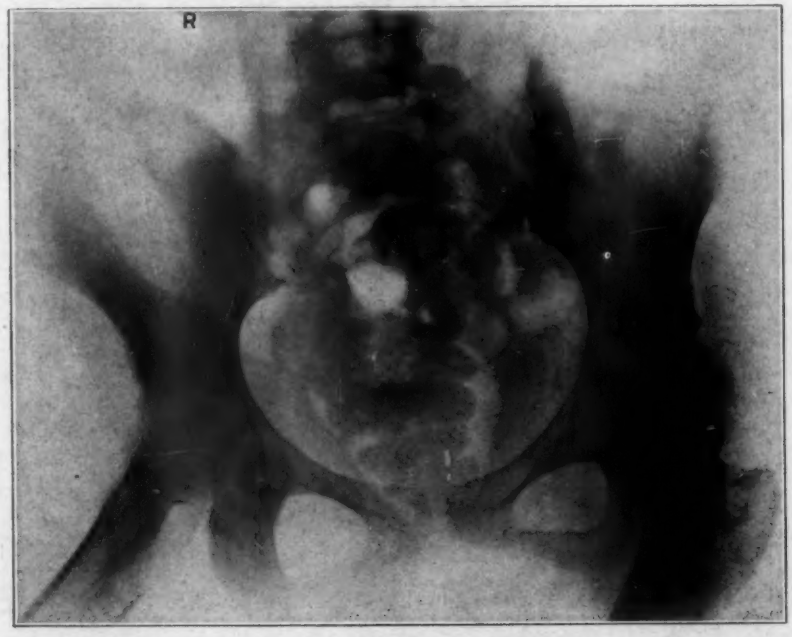

Fig. 15 (patient D. B.).—Septic arthritis of the right hip joint with the hip in position of stability. The normal left extremity was held in the position of instability for purpose of support and instinctive traction of involved right extremity. Note the threatening dislocation of the left femoral head from the acetabulum, which was corrected by application of skin traction to both extremities, relieving muscle spasm and pain.

During the acute tender stage of anterior poliomyelitis with involvement of the lower extremities, the position of stability may be maintained by proper apparatus. With the disappearance of the muscle tenderness, an analysis of the function of the muscles surrounding the hip joint will determine the position in which the extremity is to be immobilized, while an attempt is being made for restoration of muscle function. If the adductor and flexor groups of muscles are stronger

than the opposing groups, then apparatus is necessary to maintain the extremity in the position of stability, preventing the development of contractures of the stronger groups of muscles.

Congenital spastic paralysis, as a rule, offers numerous difficulties in treatment. Considerable progress may be made if one is treating a child with fair mentality and cooperative parents. Exercises for the purpose of improving coordination of muscle groups and the prevention of contractures must be employed as early as possible. If the attitude of instability threatens to develop, definite improvement

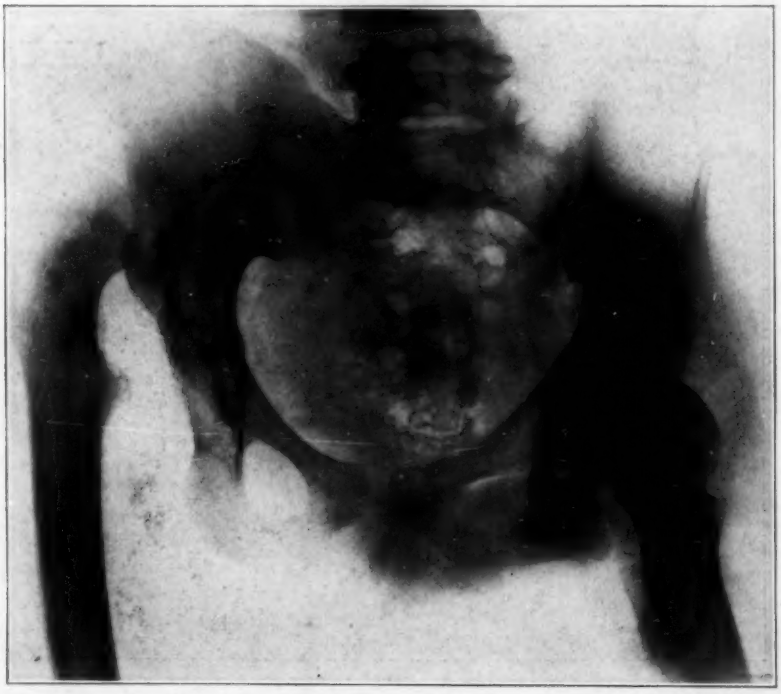

Fig. 16 (patient F. R.).—Posterior and upward dislocation of the right femoral head. The onset of anterior poliomyelitis occurred before the patient began walking. The differential diagnosis between congenital and spontaneous dislocation is not possible.

often results following a correction of the contractures and obturator neurectomy.

The treatment of patients with an established deformity offers a complicated problem with each case. Frequently the dislocation is a minor lesion, as compared with the associated deformities involving other joints. This is especially true in the paralyses, in which spinal curvature and deformities of the knees and feet may be present, demanding correction before any attention is directed toward reduction of the dislocation.

The treatment of a patient with a dislocation resulting from disturbance of muscle arrangement due to muscle spasm, if seen early, offers a fair prognosis for a functional hip joint. Incision and drainage of abscesses is done, if necessary, and skin traction is applied to the dislocated extremity. The traction is first applied in the line of deformity, and, with the gradual disappearance of muscle spasm, the line of traction is changed by degrees to a position of extension and abduction. Complete reduction was accomplished in two cases by this method, and the patients at the present time, several weeks after reduc-

Fig. 17 (patient G. B.).—Postpartum septic arthritis of the right hip joint; the hip is in a position of instability with pathologic fracture of the femoral neck. It would be difficult to rule out posterior dislocation of the femoral head from the acetabulum in the presence of inflammatory reaction with obliteration of bony landmarks.

tion, are free from active infection and muscle spasm, with a fair range of active hip joint motion.

The degree of disability depends on several important factors: disturbance of weight bearing line; true and apparent shortening; bone and joint destruction; mobility; stability; unilateral or bilateral involvement of the hip joint; associated deformities, and pain.

Stability and mobility are both important factors in the function of the hip joint, stability being the more important. A stable

and painless hip joint in a good position for weight bearing may be obtained by preliminary skeletal traction, correcting the shortening and pulling the femoral head opposite the acetabulum, followed by arthrodesis of the joint. Two patients of group 1 were definitely improved by this procedure. Fibrous or bony ankylosis between the femoral head and the ilium must be eliminated preliminary to skeletal traction in order to bring the femoral head opposite the acetabulum. In the presence of a bony ankylosis between the femoral head and ilium, a subtrochanteric osteotomy may improve the weight-bearing line and correct the apparent shortening. An attempt to correct the factors

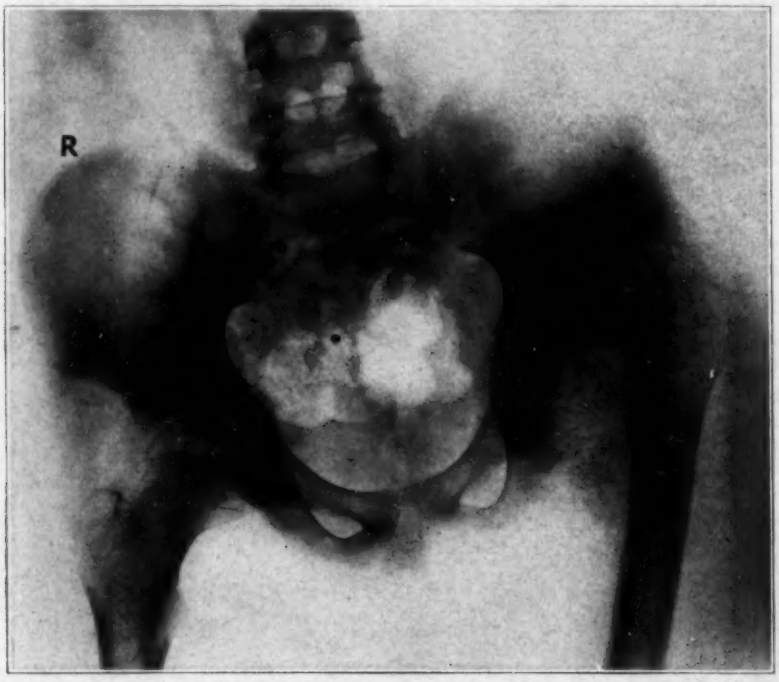

Fig. 18 (patient S. R.).—Purulent arthritis of the left hip with epiphyseal separation; note the position of instability. With obliteration of bony landmarks, due to inflammatory reaction, it would be difficult to rule out posterior dislocation of the femoral head from the acetabulum.

producing disability and to obtain motion is definitely indicated when an ankylosis exists in the opposite hip joint. Preliminary skeletal traction followed by manipulation in an attempt to reduce the femoral head in the acetabulum may be indicated when there has been slight if any bone and joint destruction.

The Lorenz [5] bifurcation operation for the purpose of improving stability and correcting the weight-bearing line was not performed in

5. Lorenz, A.: New York M. J. **117**:130, 1923.

any case reported in this paper. Transplantation of the origin of the tensor fascia lata muscle posteriorly, after the method of Dickson,[6] to improve the stability of the hip joint, was done in two cases in group 2. The stability was appreciably improved in one case.

Mr. H. A. T. Fairbank[7] states that "careful selection of cases suitable for operation is necessary, as in many the extent and severity of the paralysis contraindicate any attempt being made to stabilize the joint."

The dislocation resulting from muscle incoordination in congenital spastic paralysis, as a rule, is not difficult to reduce following preliminary correction of muscle contractures and obturator neurectomy; from my experience, the resulting improvement in function may be entirely disappointing. Continued efforts of the surgeon and of the physiotherapist over a period of many months may not result in any improvement of muscle coordination, on which the ultimate result depends. Unlimited patience and enthusiasm are important factors in dealing with this group of patients.

Improving the stability of the joint by means of forming a new acetabular roof by turning down a bone flap from the side of the ilium, as suggested by Dickson[8] and Jones,[9] was not attempted in this group of patients.

Reefing of the capsule, as performed by Sir Robert Jones,[10] was also not attempted. R. Watson Jones states that, "altho such a procedure may possibly augment the stability of the joint, it cannot supplant the necessity for the prevention of unbalanced muscular action, for, as has been insisted, contractile muscle is stronger than elastic ligament."

Deformities of the knees, feet and joints of the upper extremities are frequently combined with the dislocation of the hip joint in polyarticular arthritis or Still's disease. In one patient of group 4, associated deformities of the opposite hip, knees and feet were improved, following which the dislocation was partially reduced by means of preliminary skeletal traction and manipulation, gaining a definite improvement of function.

Preliminary skeletal traction, followed by manipulation with a satisfactory reduction of the femoral head in the acetabulum, was accomplished in two patients in whom a positive diagnosis of tuberculosis of the hip joint was made. One does not encourage this procedure in the presence of tuberculous arthritis. The positive diagnosis in either case was made subsequent to the foregoing treatment.

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6. Dickson, F. D.: J. Bone & Joint Surg. **9**:1, 1927.
7. Fairbank, H. A. T.: Proc. Roy. Soc. Med. (Sec. Orth.) **16**:15, 1923.
8. Dickson, F.: J. Bone & Joint Surg. **6**:262, 1924.
9. Jones, E.: J. Orthop. Surg. **2**:183, 1920.
10. Jones, Sir R., and Lovett, R.: Orthopedic Surgery, New York, William Wood & Company, 1924, p. 464.

TABLE 3.—*Analysis of Twenty-Eight Cases*

Case	Sex	Age at Onset of Disease	Date and Age of Original Admission		Date of Admission for Treatment of Dislocation	Etiology: Septic Arthritis Secondary to	Hip Involved	Attitude of Dislocated Hip Before Treatment	X-Ray Report	Culture and Pathologic Reports	Treatment	Present Condition
1	M	10 yr.	3/ 6/26	12 yr.	5/ 6/26	Acute rheumatic fever	Left	Flexion adduction, internal rotation	Left hip: no bony destructive changes; upward and posterior dislocation of the head of the femur	Chronic productive inflammation	Preliminary skeletal traction; arthrodesis of left hip	Bony ankylosis of the left hip, in good position for weight bearing
2	M	6 yr.	4/27/26	6 yr.	4/27/26	Scarlet fever	Bilateral dislocation	Flexion adduction, internal rotation	Bilateral posterior and upward dislocation of the heads of femora; no gross bony destructive changes	Chronic pyogenic infection; no tubercles	Preliminary skeletal traction, followed by manipulation under anesthesia (left hip)	Bony ankylosis of the right dislocated hip in good position for weight bearing; partial reposition of the left femoral head in acetabulum with fair motion
3	M	3 yr.	10/ 4/26	4 yr.	10/ 4/26	"Influenza"	Left	Flexion adduction, internal rotation	Left hip: posterior and upward dislocation of the head of the femur with formation of secondary acetabulum; no gross bony destructive changes	....	Preliminary skeletal traction followed by manipulation of left hip under anesthesia	Partial reposition of left femoral head in acetabulum with improvement in weight-bearing line
4	F	3 yr.	2/16/28	3 yr.	2/16/28	Cervical adenitis and suppurative axillary adenitis	Left	Flexion adduction, internal rotation	Left hip: posterior and upward dislocation of the head of the femur; questionable early destructive changes of acetabulum, and femoral neck	.....	Adhesive skin traction, gradually obtaining abduction, and extension	Left femoral head reduced in acetabulum; abducted position maintained at present by plaster hip spica
5	F	6 yr.	10/25, 27	6 yr.	10/25/27	Tonsillectomy (aspiration pneumonia)	Bilateral dislocation	Flexion adduction, internal rotation	Bilateral destructive lesions involving the head, neck and upper shaft of femora with bilateral posterior and upward dislocation of the heads of femora and bilateral epiphyseal separation	Chronic purulent osteomyelitis; Staphylococcus aureus	Bilateral arthrotomy; bilateral saucerization of femoral shafts; bilateral excision of upper femoral epiphyses	Bilateral discharging sinuses; physiologic position of extremities maintained at present by adhesive traction
6	F	9 yr.	9/ 7/25	9 yr.	9/ 7/25	"Influenza"	Bilateral; right hip dislocated	Flexion adduction, internal rotation	Destructive process involving both femoral heads and acetabular cavities with posterior and upward dislocation of the head of the right femur	Chronic productive inflammation; no tubercles	Preliminary skeletal traction, and right obturator nerve block followed by open reduction of the right hip	Head of right femur reduced in acetabulum with fibrous ankylosis; attitude of flexion and adduction tends to recur
7	F	3 yr.	3/21/28	3 yr.	3/21/28	Otitis media	Left	Flexion abduction, external rotation	Left femur: posterior and upward dislocation of the head of the femur; there are beginning bony changes in the head of the femur and acetabulum	Streptococcus hemolyticus	Incision and drainage of abscess of left hip joint followed by adhesive traction	Left femoral head partially reduced in acetabulum; abducted position maintained at present by skin traction

8	F	6 yr.	11/30/27	27 yr.	.....	Acute osteomyelitis of left tibia	Right	Flexion adduction, internal rotation	Right hip: posterior and upward dislocation of the femur; the head of the femur is not apparent; the neck of the femur and acetabulum show changes in development mainly due to non-weight bearing	.....	No treatment	Patient walks with fair gait; right hip is fairly stable with fair motion; the shortening due to the dislocation is compensated by shortening of the left tibia and fibula, primarily involved with osteomyelitis
9	M	16 yr.	2/ 5/27	17 yr.	2/ 5/27	Otitis media	Right	Flexion adduction, internal rotation	Right hip: destructive lesion involving the acetabulum, head and neck of the femur; posterior and upward dislocation of the head of the femur with formation of a secondary acetabulum	. .....	Preliminary skeletal traction; arthrodesis of the right hip	Bony ankylosis of the right hip in good position for weight bearing
10	M	11 yr.	5/15/24	14 yr.	2/18/28	Infection of the upper respiratory tract	Bilateral; left hip dislocated	Flexion adduction, internal rotation	Destructive lesion involving the femoral head and outer portion of the roof of the acetabulum on the right side; on the left side are multiple areas of destruction involving the neck of the femur and outer portion of the shaft just distal to the greater trochanter	Streptococcus hemolyticus	Subtrochanteric osteotomy of the right femur	Postoperative death due to pyemia
11	M	14 yr.	11/23/23	15 yr.	.....	Osteomyelitis of the pelvis	Bilateral; right hip dislocated	Flexion adduction, internal rotation	Left hip: marked destructive lesion involving the head and neck of the femur and the entire left ilium; right hip: destructive bony lesion involving the acetabulum, head, neck and trochanter of the right femur with posterior and upward dislocation	Staphylococcus aureus; chronic purulent osteomyelitis	Incision and drainage of multiple abscesses	Death following chronic suppuration
12	M	9 yr.	2/ 2/23	9 yr.	6/ 6/26	Pneumonia	Left	Flexion adduction, internal rotation	Left hip: marked destructive process involving the entire left hip joint and bone surrounding the acetabulum, with posterior and upward dislocation of the head of the left femur	Chronic pyogenic infection; diplococcus pneumoniae (empyema culture)	Preliminary skeletal traction; arthrodesis of the left hip	Operative death; autopsy report: thymicolymphatic constitution
13	M	17 yr.	9/16/24	19 yr.	1/10/28	Acute osteomyelitis primary in the left clavicle	Left	Flexion adduction, internal rotation	Left hip: bony destructive process involving the head and neck and acetabulum with resulting ankylosis; posterior and upward dislocation of the head of the femur	Staphylococcus albus	Subtrochanteric osteotomy of the left femur	Improved weight-bearing line following osteotomy
14	M	14 yr.	7/18/24	14 yr.	1/ 5/28	"Influenza"	Bilateral right hip dislocated; left epiphyseal separation	Flexion adduction, internal rotation	Bilateral destructive process involving both hip joints; posterior and upward dislocation of the head of the right femur; on the left side there is an epiphyseal separation with posterior and upward displacement of the femoral neck	Staphylococcus aureus; chronic purulent osteomyelitis; no tubercles	Open reduction of the right femoral head in acetabulum	Bony ankylosis of the left hip in poor position for weight bearing; recent open reduction wound infected

TABLE 3.—*Analysis of Twenty-Eight Cases—Continued*

Case	Sex	Age at Onset of Disease	Date and Age of Original Admission		Date of Admission for Treatment of Dislocation	Etiology: Septic Arthritis Secondary to	Hip Involved	Attitude of Dislocated Hip Before Treatment	X-Ray Report	Culture and Pathologic Reports	Treatment	Present Condition
15	M	3 yr.	4/19/28	55 yr.	.....	"Influenza"	Bilateral dislocation	Flexion adduction, internal rotation	Bilateral destructive process of both hip joints with bilateral posterior and upward dislocation with ankylosis	Staphylococcus aureus	Incision and drainage of abscess	Bilateral bony ankylosis of hip joints; marked disability in gait; ambulatory without crutches
16	M	2 yr.	4/28/28	22 yr.	.....	Wound infection of face	Right	Flexion adduction, internal rotation	Right hip: posterior and upward dislocation; complete destruction of femoral head; changes of femoral neck and acetabulum due to abnormal weight bearing	.....	Treatment not advised	Patient is ambulatory with lift on shoe partially compensating for shortening; motion is painless; hip joint is hypermobile; there is 4½ inches shortening
						Paralysis of Anterior Poliomyelitis						
17	F	19 mo.	5/13/25	6 yr.	5/ 4/27	Function of hip muscles: flexors, good; extensors, poor; abductors, poor; adductors, good; tensor fascia lata, good	Right	Flexion adduction, internal rotation	Right hip: posterior and upward dislocation; no bony changes	.....	Tensor fascia lata transplant	Stability of hip joint not improved by tensor fascita lata transplant
18	F	3 yr.	11/22/26	13 yr.	.....	Function of hip muscles: flexors, good; extensors, zero; abductors, zero; adductors, normal; tensor fascia lata, normal	Right	Flexion adduction, internal rotation	Right hip: posterior and upward dislocation of the head of the femur; no bony changes	.....	Treatment refused	Fair gait with brace applied; slight instability of right hip
19	M	2 yr.	5/14/26	5 yr.	1/28/27	Function of hip muscles: flexors, normal; extensors, zero; abductors, zero; adductors, good; tensor fascia lata, fair	Left	Flexion adduction, internal rotation	Left hip: posterior and upward dislocation of the head of the femur; no bony changes	.....	Tensor fascia lata transplant	Stability of the hip joint improved following tensor fascia lata transplant
20	M	19 mo.	8/ 7/26	22 mo.	8/ 7/26	No record	Left	Flexion adduction, internal rotation	Left hip: posterior and upward dislocation of the head of the femur; no bony changes	.....	Braces applied; extensive paralysis of both lower extremities	Walks with long braces and crutches

								Congenital Spastic Paralysis				
21	F	Birth	9/21/27	23 yr.	9/21/27	Congenital spastic paralysis	Right	Flexion adduction, internal rotation	Right hip: posterior and upward dislocation of the head of the femur with marked changes in the acetabulum, head and neck of the femur due to nonweight bearing	.....	Bilateral obturator neurectomy for painful adductor spasm	Pain relieved following obturator neurectomy
22	F	Birth	2/21/25	9 yr.	2/24/25	Congenital spastic paralysis	Left	Flexion adduction, internal rotation	Left hip: posterior and upward dislocation of the head of the femur with no bony changes	.....	Bilateral obturator neurectomy; manipulation under anesthesia	Femoral head reduced in acetabulum but gait not improved
23	F	Birth	1/11/27	4 yr.	1/11/27	Congenital spastic paralysis	Left	Flexion adduction, internal rotation	Left hip: posterior and upward dislocation of the head of the femur with no bony changes	.....	Bilateral obturator neurectomy; adhesive skin traction and manipulation under anesthesia	Reduction of femoral head in acetabulum by manipulation under anesthesia failed; second manipulation to be attempted
24	F	Birth	1/19/28	7 yr.	5/18/28	Congenital spastic paralysis	Left	Flexion adduction, internal rotation	Left hip: posterior and upward dislocation of the head of the femur with no bony changes	.....	Bilateral obturator neurectomy followed by preliminary skin traction and manipulation under anesthesia	Femoral head reduced in acetabulum by manipulation under anesthesia; position maintained at present in plaster hip spica
								Chronic Polyarticular Arthritis "Still's Disease"				
25	F	4 yr.	4/19/27	11 yr.	4/19/27	Chronic polyarticular arthritis "Still's disease	Bilateral; left hip dislocated	Flexion adduction, internal rotation	Left hip: posterior and upward dislocation of the head of the femur with atrophic bony changes; right hip: destructive changes involving the femoral head and acetabulum with a loss in joint space	....	Wedging plasters correcting flexion deformities of the knees and hips	Flexion deformities practically corrected; patient is gradually becoming ambulatory after a period of 6 years recumbency
26	F	13 mo.	1/14/25	7 yr.	1/14/25	Chronic polyarticular arthritis "Still's disease	Bilateral; left hip dislocated	Flexion adduction, internal rotation	Left hip: posterior and upward dislocation of the head of the femur with atrophic changes of the head and neck of the fumur; right hip: destructive lesion involving the femoral head and acetabular cavity	.....	Wedging plasters correcting flexion deformities of the knees and hips, followed by skeletal traction and manipulation under anesthesia	Ambulatory without braces; gait is fair; patient had been recumbent for a period of 6 years
								Tuberculous Arthritis				
27	M	6 yr.	9/ 1/26	7 yr.	9/ 1/26	Tuberculous arthritis	Bilateral; left hip dislocated	Flexion adduction, internal rotation	Right hip: destructive lesion without bone regeneration involving the femoral head, neck and acetabulum; left hip: posterior and upward dislocation with no destructive changes	Guinea-pig report: positive evidence of tuberculosis	Preliminary skeletal traction; manipulation under anesthesia; motion discontinued on guinea-pig report	Recumbent with both hips immobilized in physiologic position; complete reduction of left hip in acetabulum
28	F	5 yr.	9/16/26	6 yr.	9/16/26	Tuberculous arthritis	Bilateral; left hip dislocated	Flexion adduction, internal rotation	Right hip: destructive process involving the neck, femoral head and acetabulum without bone regeneration; left hip: posterior and upward dislocation with a destructive lesion involving the head of the femur and acetabulum	Guinea-pig report: positive evidence of tuberculosis	Preliminary skeletal traction; manipulation under anesthesia	Death following chronic suppuration

CONCLUSIONS

1. Spontaneous dislocation of the hip joint is a preventable deformity.

2. The mechanism of the development of the dislocation is a disturbance of the normal action of the muscles surrounding the hip joint, first emphasized by R. Watson Jones.

3. The disturbance of muscle action may be caused by (*a*) paralyses of anterior poliomyelitis with the development of contractures, (*b*) muscle spasm associated with an infectious process of the hip joint and (*c*) muscle incoordination of congenital spastic paralysis.

4. Flexion, adduction and internal rotation of the hip should be considered a dangerous attitude.

5. Spontaneous dislocation of the hip joint is essentially a condition developing during early life.

6. Treatment of a patient with an established deformity is highly unsatisfactory, and frequently the dislocation is a minor deformity compared to associated deformities of other joints.

7. Muscle spasm, which is the disturbing factor during the acute stage of infectious arthritis of the hip joint, should be relieved by skin traction maintaining the involved extremity in the position of stability —abduction and extension.

8. Bilateral involvement of the hip joint is frequent in the infectious group.

9. Instinctive traction and support by the normal extremity should be prevented, since it places the uninvolved hip in the position of instability and favors bilateral involvement of the hip joint.

EFFECT OF INJECTIONS OF HYDROCHLORIC ACID ON THE GASTRIC AND DUODENAL MUCOSAE*

WILLIAM J. GALLAGHER, M.D.
CHICAGO

In a previous communication,[1] it was shown that acute traumatic lesions of jejunal transplants to the stomach healed readily in the presence of artificial hyperacidity. I shall now report the changes observed in the gastric and duodenal mucosae of those experiments and further observations in a group of control animals fed acid solution.

EXPERIMENTAL PROCEDURE AND RESULTS

The experimental procedure was described in a previous report.

Briefly, after recovery from the intestinal transplant operation, a group of seven animals were fed acid solution through a stomach tube once or twice daily in amounts of from 200 to 225 cc. and in concentrations of 0.22, 0.29 and 0.62 per cent by weight.

A group of six control dogs was similarly studied, into which 0.62 per cent acid solution was injected two or three times daily. The injections were given daily from ten to eighty days. On various occasions, the contents of the stomach of several of the dogs were aspirated from four to five hours after the injections of acid. The animals were kept on a diet of meat, bones, bread and water. After daily injections had been given for about one month, there was considerable loss of weight, but emaciation did not occur in any of the dogs. Acidosis was observed in several, most of which were then killed. Immediately after the death of the dogs, specimens were excised for microscopic examination and placed in Zenker's fluid to prevent postmortem changes.

In the group of seven animals in which jejunal transplants had been made, vomiting was frequent, especially with the higher concentration of acid solution. From 8 to 30 cc. of contents was obtained at different times on aspiration five hours after injection, while in the control experiments, the stomachs were always empty after five hours.

Mucus was frequently present in the vomitus and was constantly present in the stomachs. Blood stained mucus and tarry stools were observed in two dogs.

The changes in the mucosa of the stomach were more extensive with the higher concentration of acid solution and the more frequent injection,

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* From the Seymour Coman Fellowship in the Department of Physiology of the University of Chicago and the Department of Surgery of Rush Medical College of the University of Chicago.

1. Gallagher, W. J.: Arch. Surg. **17**:279 (Aug.) 1928.

Fig. 1.—Stomach of dog 7 with jejunal transplant. Note acute ulcer of pyloric mucosa with gastritis and erosions of fundal mucosa.

Fig. 2.—Acute ulcer in figure 1. Note cellular infiltration of mucosa and submucosa; × 50.

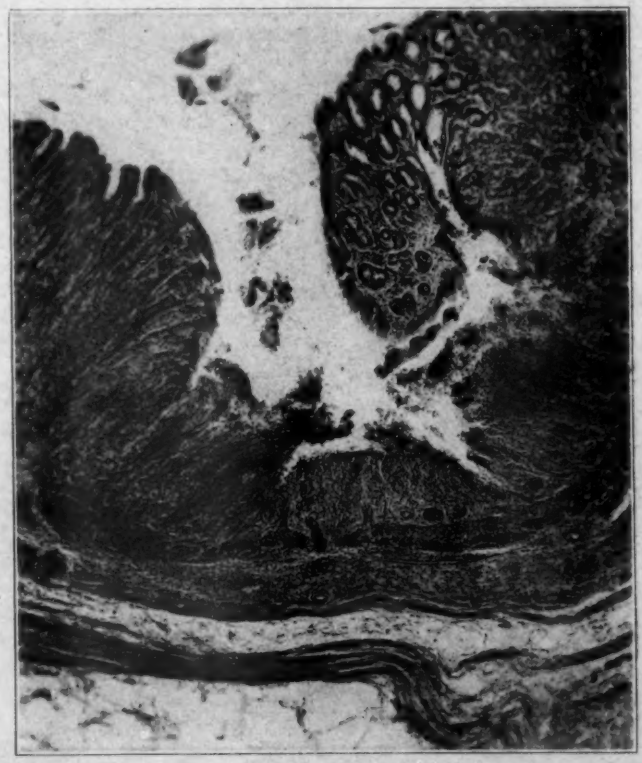


Fig. 3.—Deep erosion of fundal mucosa in figure 1 with cellular infiltration of mucosa and submucosa; × 50.

especially in the experiments with jejunal transplant in which there was often some delay in the emptying time of the stomach.

The most marked changes were always observed in the fundal mucosa. Briefly, these were acute and chronic gastritis with superficial and deep erosions and acute ulcers in a few animals; in one, a chronic ulcer, 3 by 1.5 cm., was located on the middle of the anterior wall. This dog had been fed 0.62 per cent acid solution from one to two times daily for fifty-nine days. A jejunal transplant was also on the anterior wall,

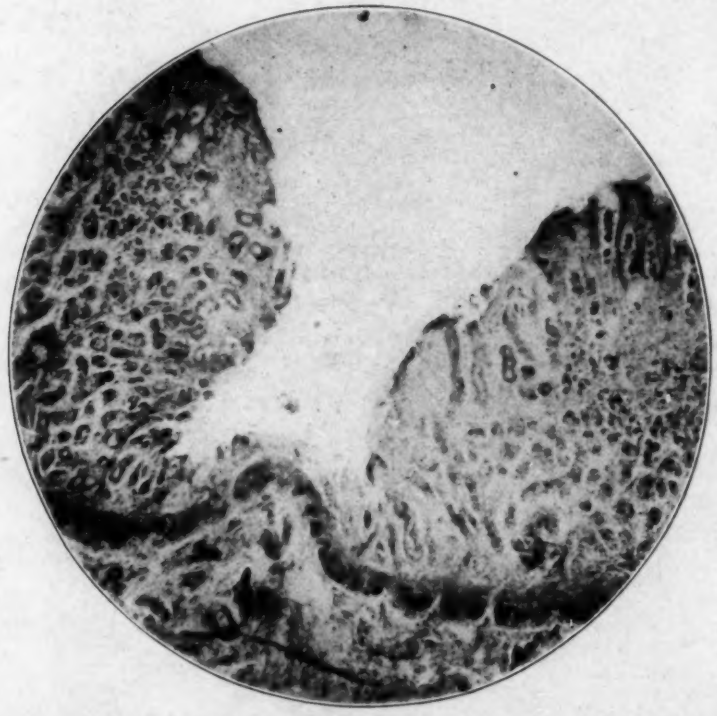


Fig. 4.—Deep erosion of fundal mucosa in figure 1. Note slight cellular exudate; × 50.

but was not in any way connected with the chronic ulcer. The base of the ulcer was formed by submucosa which contained considerable scar tissue; there was little change in the muscularis, and there was only slight cellular infiltration about the ulcer. In three animals, acute erosions were present in the pyloric mucosa. Two of these were in the group of control animals. Two acute ulcers, 5 by 3 mm. were observed in the pyloric mucosa near the lesser curvature in one dog fed 0.62 per cent acid twice daily for twenty-five days.

Fig. 5.—Stomach of dog 6 with (*A*) jejunal transplant showing opening into upper blind loop and (*B*) chronic gastric ulcer outlined by arrows.

TABLE 1.—*Effect of Injections of Hydrochloric Acid on Gastric and Duodenal Mucosae* *

Dog	Injections of Hydrochloric Acid: Percentage	Amount of Each Injection, Cc.	Number of Days	Necropsy: Results	Necropsy: Histologic Studies
1	0.22	200	33	Stomach dilated, contains mucus; congestion and swelling of gastric mucous membrane; a few superficial erosions in fundus	
2	0.29	200	56	Congestion, swelling, petechial hemorrhages and superficial erosions 1 to 2 mm. in size; mucus present; area of redness, 1 cm. in size, on posterior wall of duodenum near pylorus	Superficial and deep erosions with some cellular infiltration of gastric mucosa; some cellular infiltration of duodenal mucosa
3	0.22 0.62	200 200 twice daily	53 29	Blood stained mucus in stomach; many erosions in fundus, a few in antrum, 1 to 3 mm. in size; two acute ulcers in fundus 2 by 1 cm.; first 4 cm. of duodenal mucosa on posterior wall are reddened and contain two erosions 1 to 2 mm. in size; tarry material in colon; edema and redness generally of gastric mucosa	Acute ulcers extend into submucosa; cellular infiltration of submucosa, with eosinophils and round cells; a few fibroblasts at base of ulcers; cellular infiltration of mucosa in many areas; deep and superficial erosions
4	0.22	200	32	Some mucus in stomach; edema and redness but no gross erosions of gastric mucosa	
5	0.62	200	60	Mucus in stomach; edema and redness of gastric mucosa with superficial erosions in fundus, 1 to 2 mm. in size	Eosinophils and round cells in mucosa and submucosa; exudate in mucosa; superficial and deep erosions present
6	0.62 0.62	200 225 twice daily	27 32	Much mucus in stomach; edema, petechiae and several erosions of fundal mucosa, 1 to 2 mm. in size; chronic ulcer of the gastric mucosa, 3 by 1.5 cm., on anterior wall middle of fundus; hard, gray base; mucosa puckered about ulcer	Much exudate on surface of mucosa which contains superficial and deep erosions and marked cellular infiltration in duodenum; scar tissue in base of chronic ulcer for 2 mm. beneath mucosa on either side of ulcer; base formed by submucosa; little cellular infiltration of ulcer
7	0.62 0.62	200 200 twice daily	19 6	Much mucus in stomach; edema, redness, many erosions of gastric mucosa, the largest 1 cm. in diameter; two acute ulcers near lesser curvature of pylorus, 5 by 3 mm.; 2 cm. of posterior wall of duodenum are reddened	Superficial and deep erosions with round cells and eosinophils in mucosa of stomach; much exudate with round cells, eosinophils in duodenal mucosa

* These animals had jejunal transplants to the stomach for from 41 to 154 days. There was some tendency to retention and more frequent vomiting after acid injection than in the control dogs fed acid solution.

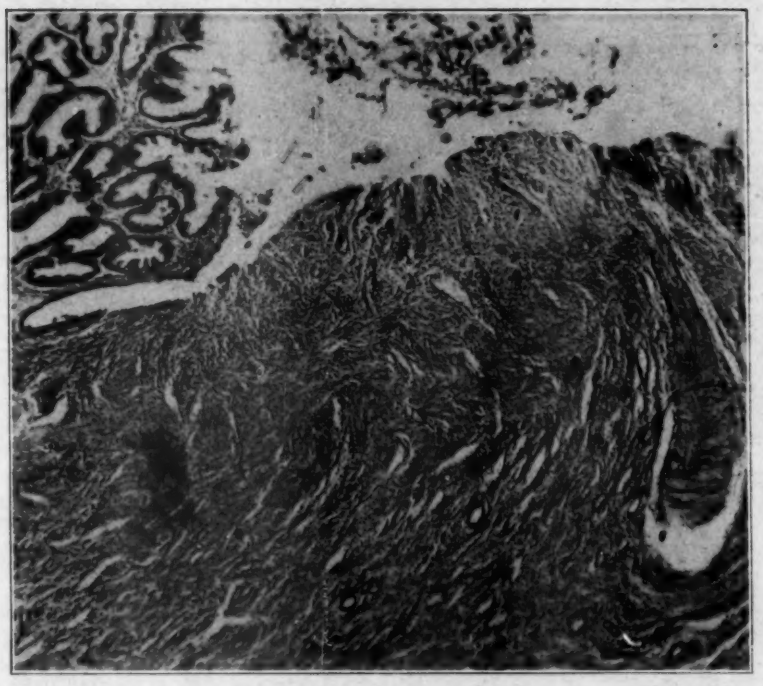


Fig. 6.—Chronic ulcer in figure 5. Note the scar tissue in base and the proliferative single layer of cells at the margin; × 50.

Fig. 7.—Healing erosion of fundal mucosa in figure 6 with cellular infiltration; × 80.

Four of the controls did not show gross change or only slight thickening of the pyloric mucosa. Mucus was usually found in this region in large quantities.

A localized duodenitis with superficial erosions was observed near the pylorus and usually on the posterior wall in four of the seven experiments in which jejunal transplants were made, and in five of the six controls. In three, gross erosions were present in the area of redness in the duodenum.

Fig. 8.—Fundal mucosa showing marked cellular infiltration of mucosa and submucosa; × 50.

Histologic studies were made in most of the experiments. Sections were taken from various parts of the gastric mucosa and from the inflamed areas of the duodenal mucosa.

In many areas of the fundal and duodenal mucosae, cellular infiltration was marked. In the acute regions, exudate with polymorphonuclear leukocytes was observed. In the more chronic lesions, round cells, plasma cells and eosinophils were present.

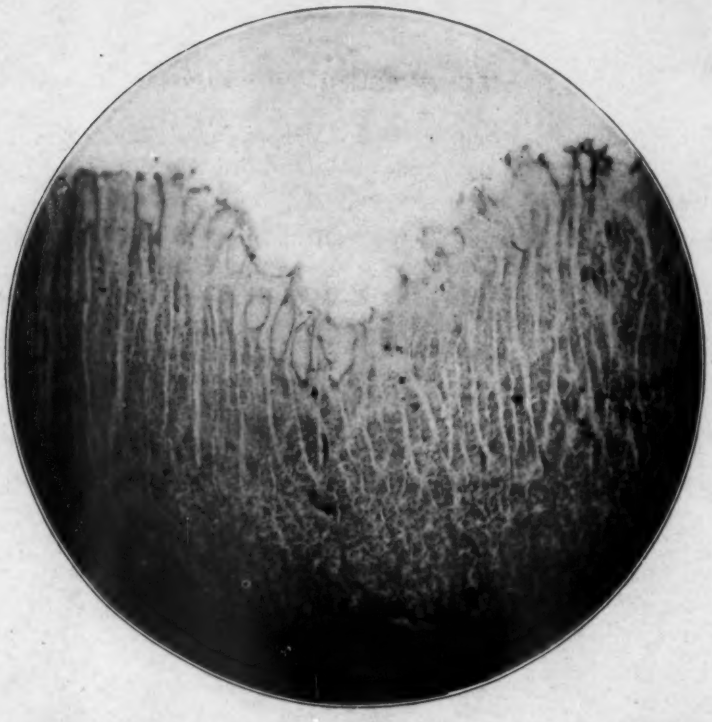


Fig. 9.—Stomach of control dog 5 showing a superficial erosion of fundal mucosa with only slight cellular infiltration; × 50.

Fig. 10.—Large deep erosion of gastric mucosa of control dog 1; × 32.

The erosions were superficial and deep, some extending to the submucosa. In some erosions, cellular infiltration was slight; in others, it was marked and in places extended into the submucosa. The lesions extending into the submucosa were termed ulcers. Where the erosions

TABLE 2.—*A Series of Injections of Hydrochloric Acid Into Stomach of Normal Dogs**

	Injections of Hydrochloric Acid			Necropsy	
Dog	Percentage	Amount of Each Injection, Cc.	Number of Days	Results	Histologic Studies
1	0.62	225 two to three times daily	80	Tarry material in colon; blood stained mucus in stomach; edema, redness, many erosions of fundal mucosa 1 to 2 mm. in size, also an acute ulcer, 8 by 3 mm.; petechiae, redness of mucosa of duodenum for 6 cm. from pylorus	Exudate and cellular infiltration of gastric mucosa with superficial and deep erosions; cellular infiltration and exudate of duodenal mucosa, many lymph follicles in mucosa of duodenum
2	0.62	225 twice daily	31	Edema and redness of fundal mucosa; much mucus in stomach; pyloric mucosa normal grossly; edema and redness of duodenal mucosa for 6 cm. from pylorus	
3	0.62	200 three times daily	10	Mucus in stomach; a few erosions of pyloric mucosa 1 mm. in size; edema and redness of fundal mucosa on posterior wall of duodenum is an erosion 3 by 1 mm. which is surrounded by redness for 1 to 2 cm. and 0.5 cm. from pylorus	Superficial and deep erosions of gastric and duodenal mucosa, 1 to 2 mm. in size, with cellular infiltration and exudation
4	0.62	200 twice daily	29	Mucus in stomach; edema, redness and many erosions of gastric mucosa, 1 to 10 mm. in size; erosions 1 to 2 mm. in size near lesser curvature of pylorus; redness for 5 cm. and a few erosions 1 mm. in size on the posterior wall of duodenum	Superficial and deep erosions of gastric and duodenal mucosa; some cellular infiltration
5	0.62	200 twice daily	41	Redness and swelling of fundal mucosa with several erosions 1 to 2 mm. in size	Exudate, cellular infiltration, superficial and deep erosions of gastric mucosa, also of duodenal mucosa
6	0.62	200 twice daily	36	Mucus present in stomach; edema, redness and erosions of fundal mucosa 1 to 2 mm. in size with similar changes in the first 1 to 2 cm. of the posterior wall of the duodenum	Superficial and deep erosions with cellular infiltration of the gastric and duodenal mucosa; some exudate on the surface

* Acidosis frequently developed after which the animal was usually killed.

were superficial, exudate was usually limited to the mucosa, and in many areas exudate poured from the eroded tubules.

In the pyloric and duodenal mucosae, these inflammatory changes were usually localized, while in the fundal mucosa they were frequently diffuse.

COMMENT

Bolton [2] observed similar changes in the stomachs of cats and monkeys, but he used much higher concentrations of acid solution.

Carlson [3] and recently Palmer [4] have found 0.5 per cent of hydrochloric acid in the analysis of gastric secretions of normal dogs; 0.62 per cent is higher than normally found. However, the changes produced in animals given 0.22 and 0.29 per cent acid differed only in degree

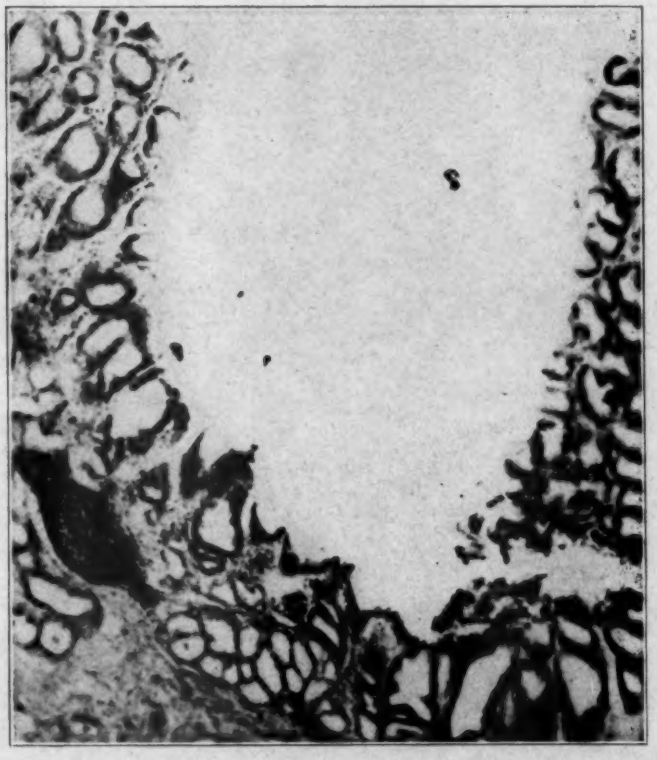


Fig. 11.—Deep erosion on the posterior wall of the duodenum of control dog 3, with cellular infiltration. Note Brünners glands at base of erosion; × 43.

from those in animals fed the stronger solution; in all other respects, they were similar, which is in accord with the observations of Bolton.[2]

A delayed emptying time, observed in the stomachs of some of the dogs in which jejunal transplants had been made, caused more changes in the gastric mucosa. This is probably due to a longer contact of the

2. Bolton, Charles: The Part Played by the Acid of the Gastric Juice in the Pathological Processes of Gastric Ulcer, J. Path. & Bact. **20**:133, 1915-1916.

3. Carlson, A. J.: Personal communication to the author.

4. Palmer, W. L.: Personal communication to the author.

irritating acid solution with the mucosa. The more frequent vomiting in these animals, however, lessened the time of contact to some extent. Gravitation of mucus to the pylorus with regurgitation of alkaline intestinal contents and the alkaline secretion of the pyloric mucosa, no doubt, explain the few changes observed in the pyloric mucosa.

The location of the chronic gastric ulcer suggests the possibility that repeated trauma from the stomach tube and the forceful flow of acid

Fig. 12.—Control dog 4, showing superficial erosion of duodenal mucosa with marked cellular infiltration. Note Brünners glands with two lymph follicles beneath exudate; × 50.

solution from the tube produced an acute lesion which was daily traumatized by these factors. Trauma and acid solution were important in the production of this lesion.

The localized duodenitis, usually close to the pylorus, is further evidence of the irritating action of hydrochloric acid. The changes in the duodenum were never observed more than from 2 to 6 cm. distal to the pylorus. This suggests the possibility of neutralization of the acid beyond these areas. The gross and microscopic appearance of these

duodenal lesions are strikingly similar to those occurring in the human being to whom an average of 63 units of free hydrochloric acid has been given (Judd and Nagel).[5]

The gastric lesions are also grossly and microscopically similar to those described by Orator,[6] Konjetzny[7] and others in the stomachs of persons with ulcer.

Fig. 13.—Gastric mucosa of control dog 4, showing erosion of fundal mucosa. Note engorgement of vessels in submucosa; × 50.

5. Judd, E. Star, and Nagel, G. W.: Duodenitis, Ann. Surg. **85**:380, 1927.

6. Orator, V.: Beitrag zur Magenpathologie (histologische Untersuchungen annklinischen Resektionsmaterial), Virchows Arch. f. path. Anat. **255**:637, 1925.

7. Konjetzny, G. E., and Puhl, H.: Ueber die Bedeutung der Gastritis und duodenitis für die Entstehung des Magens-und Duodenal-Geschwürs, Med. Klin. **26**:986 (June) 1927.

Experimentally at least, hydrochloric acid is an important element in the production of acute and chronic gastritis with erosions and acute ulcers.

SUMMARY

The changes produced by injecting different concentrations of hydrochloric acid into the stomachs of thirteen dogs have been studied. The experiments were carried out on two groups. In one group of seven animals with jejunal transplants to the stomach, acid was injected once or twice daily in amounts of from 200 to 225 cc. of a 0.22, 0.29 or 0.62 per cent solution. Vomiting was frequent; mucus was present in the stomachs in large quantities. There was frequently some delay in the emptying time of the stomach in these animals. The greatest changes were usually present in the fundal mucosa. Acute ulcers were observed in the pyloric mucosa of two animals, while a chronic gastric ulcer of the fundal mucosa was observed in one. Repeated trauma from the stomach tube was suggested as a factor in the production of this lesion. The most constant observations were acute and chronic gastritis with multiple erosions; these changes were greater when the higher concentrations of acid were used. A localized area of duodenitis, with erosions in two, was present in four of the seven animals.

In the second group of six control animals, a 0.62 per cent solution was injected in similar amounts two or three times daily. Chronic ulcers were not observed, but changes similar to those in the stomachs and duodenal mucosae of the animals in the first group were noted, although to a lesser degree. A delay in the emptying time of the stomachs of this group was not observed.

Histologic studies were made of different parts of the gastric and duodenal mucosae showing different types of erosions, acute ulcers and cellular changes.

Attention is called to the similarity of these lesions to those found clinically in the stomach and duodenum and the probable importance of hydrochloric acid in their production.

CONCLUSIONS

1. Acute and chronic gastritis and duodenitis with multiple erosions and acute ulcers are produced by injections of hydrochloric acid into the stomachs of dogs.

2. A delay in the emptying time of the stomach causes more extensive changes of the mucosa of the stomach, and when an element of trauma is added, a chronic ulcer may occur.

3. Mucus may exert a protective influence against the corrosive action of hydrochloric acid on the gastric mucosa.

SUBMUCOUS LIPOMA OF COLON

REPORT OF A CASE

J. A. MacFARLANE, F.R.C.S. (Edin.)
Junior Demonstrator in Surgery, Department of Surgery, University of Toronto
TORONTO

History.—Mrs. H. S., aged 47, was admitted to the wards of the General Hospital on June 27, 1927, with the following history:

In September, 1926, she had been taken ill rather suddenly with cramplike abdominal pain accompanied by vomiting, without other associated symptoms. A diagnosis of appendicitis had been made; operation performed within twelve hours disclosed negative evidence in the appendix. Following the operation, however, she was well until March, 1927, when she had a similar attack of cramplike pain, which lasted about thirty hours. In the middle of the attack, she passed a blood stained stool. From that time until admission to the hospital, she had ten attacks of shorter duration than the first. In four of these, she passed stools containing blood and mucus.

Between attacks, the bowels moved regularly without the aid of a laxative, and she felt well in every way. She had not lost weight and her appetite was excellent; in fact, there was no functional disturbance other than that already noted.

On admission to the hospital, she appeared to be in excellent health; her temperature was normal, and the white and red cell count and hemoglobin content were normal. The results of the physical examination were negative. The abdomen was not distended, nor could any masses be felt. The rectal and pelvic examination did not reveal anything unusual.

Before admission to the hospital, observations made following a barium meal and a barium enema had been negative.

It was felt, however, that with such a history one could not rule out the possibility of new growths of the large bowel, without performing a laparotomy. It was decided that the operation should be performed, but in the meantime the patient had another attack of abdominal pain and again passed blood stained mucus. The barium enema was repeated, and this time the report suggested an intussusception in the transverse colon.

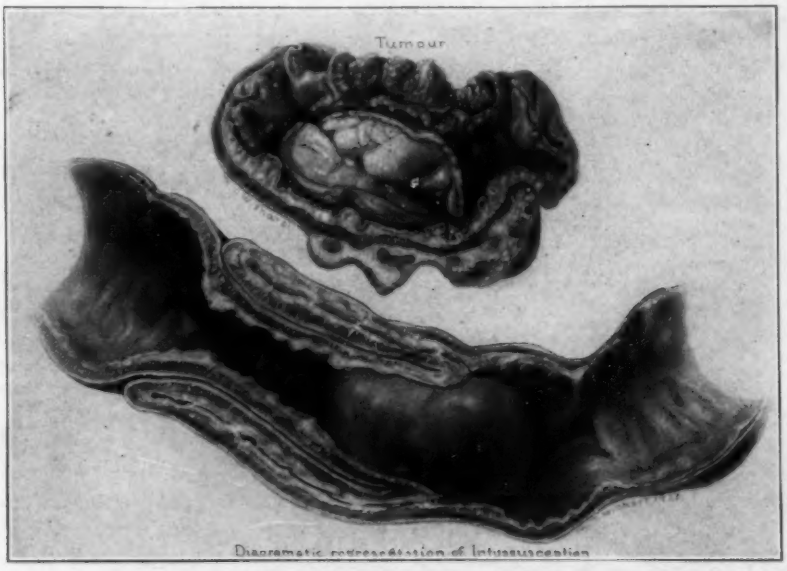
Operation.—On July 2, operation was performed under gas oxygen and local anesthesia, with a preoperative diagnosis of carcinoma of the large bowel. When the abdomen was opened, an intussusception, about 4 inches (10.16 cm.) in length, was found in the midportion of the transverse colon. It was easily reduced and had evidently occurred while the patient was being anesthetized. After reduction, a mass the size of an orange, which was immovable and fairly firm, was felt in the lumen of the bowel. With the associated edema and swelling resulting from the intussusception, the mass seemed to be a typical carcinoma of the bowel with some associated inflammatory reaction. A resection of the modified Mickulicz type was undertaken, anastomosis being made between the bowel proximal and distal to the tumor and the whole mass being brought outside the abdominal wall. In five days, the bowel containing the mass was removed with the cautery, and not until then was it discovered that the tumor was a lipoma. Grossly, it presented the appearance shown in the accompanying drawing and, microscopically, the diagnosis of submucous lipoma was confirmed. The patient

made a fairly rapid recovery and left the hospital in three weeks with a fistula at the site of the operation. She returned to the hospital two months later and the fistula was closed.

She was seen again in January, 1928, with an attack of obstruction of the small bowel, and was admitted to the hospital. An operation disclosed that the obstruction was due to a band. This was relieved, and the patient left the hospital in eighteen days. She has been well since that time.

COMMENT

Submucous lipomas of the colon are comparatively rare. The most comprehensive study found in the literature was that by P. DeRocque and A. DeRocque,[1] who made a study of all the cases reported up to



Lipoma of the colon with diagram of intussusception.

1924, numbering 104. Approximately the same number were found in the small bowel as in the colon; 34 per cent of the cases in the small intestine and 9 per cent of those in the large intestine were symptomless. In thirty-one cases, an emergency operation was performed for acute obstruction. In fifty-six cases, the patient suffered from chronic obstruction. In forty-seven of these cases, intussusception occurred, this phenomenon being more common in the small intestine than in the colon. The DeRocques suggested that the most suitable treatment is an enterostomy and enucleation of the tumor, but that in some cases in which the diagnosis is doubtful, a resection should be undertaken.

1. DeRocque, P., and DeRocque, A.: J. de chir. **24**:163 (Aug.) 1924.

Moore [2] noted that in 44,654 operations performed at the Mayo Clinic, only six cases were recorded. He reported two cases of lipoma of the sigmoid in which the lipomas were removed surgically and in which the patients made a good recovery.

Treves [3] noted that lipoma and other varieties of polyp coexist in 8 per cent of the cases of intussusception.

It would seem particularly difficult to make a diagnosis of lipoma, or, indeed, of any type of innocent tumor of the large bowel, previous to operation, and in this case, with the abdomen open, it was not possible. Tumors of this variety that reveal symptoms should rightly be regarded as malignant until definitely proved otherwise. In the pedunculated variety only, would it seem wise to open the bowel and enucleate the tumor.

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2. Moore, J. T.: Surg. Gynec. Obst. **40**:407 (March) 1925.
3. Treves: Intestinal Obstruction, p. 178.

CANCER OF THE LOWER LIP

SUGGESTIONS AS TO OPERATIVE TECHNIC IN PLASTIC REPAIR *

FRED R. FAIRCHILD, M.D.
WOODLAND, CALIF.

The motive for the presentation of this subject is to describe an operation for the reconstruction of the lip. As the necessity for the procedure arises almost wholly from cancer, the characteristics of the disease must first be considered, at least so far as they exert a modifying influence on operative technic.

In view of the claims of many competent observers that better results are obtained by radiation than by operation in the treatment of cancer of the lip, one almost feels the necessity of arguing the point to establish his right to suggest a surgical procedure. To do this would be but to add another personal opinion to one side of an argument that only further experience and the lapse of time can settle. No better illustration of the radical difference of opinion relative to the method of choice could be had than that offered by the symposium on intra-oral cancer presented before the Radiological Society of North America in November, 1926. Papers read by Ewing [1] of New York, Burnham [2] of Baltimore, Duffy [3] of New York, and Judd and New [4] of Rochester served to give the conviction that no one is certain whether irradiation or operation offers the best chance of cure. Until the question is answered, a cancer of the lip should be treated as an entity, and, after careful consideration of all modifying conditions, experience must be the guide in determining whether radiation or a surgical procedure should be used.

There cannot be any question that the poor cosmetic effect following resection of cancer of the lip is a factor that influences many patients to select treatment by radiation, even in the face of an analysis of the situation resulting in positive advice that surgical intervention would be the safer procedure. The patient will often accept an added percentage of risk to escape disfigurement. The surgeon will sometimes allow his heart to rule his head. These factors often cause the patient to insist on a conservative course; this may or may not be regrettable, if he consults a competent radiologist, but the result will surely be most unfortunate if, as so often happens, he falls into the hands of a quack.

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* From the Department of Surgery, Woodland Clinic.

* Read at the Meeting of the Pacific Coast Surgical Association held in Portland, Ore., Feb. 22-25, 1928.

1. Ewing, James: Radiology **9**:359 (Nov.) 1927.
2. Burnham, C. F.: Radiology **9**:366 (Nov.) 1927.
3. Duffy, J. F.: Radiology **9**:373 (Nov.) 1927.
4. Judd, Starr, and New, G. B.: Radiology **9**:380 (Nov.) 1927.

There is as much evidence in support of surgical procedure as the treatment of choice in cancer of the lip as there is in support of treatment by irradiation. Any discussion of an operative technic which will give better cosmetic results is vastly important, not only because it will bring satisfaction to the patient operated on, but because

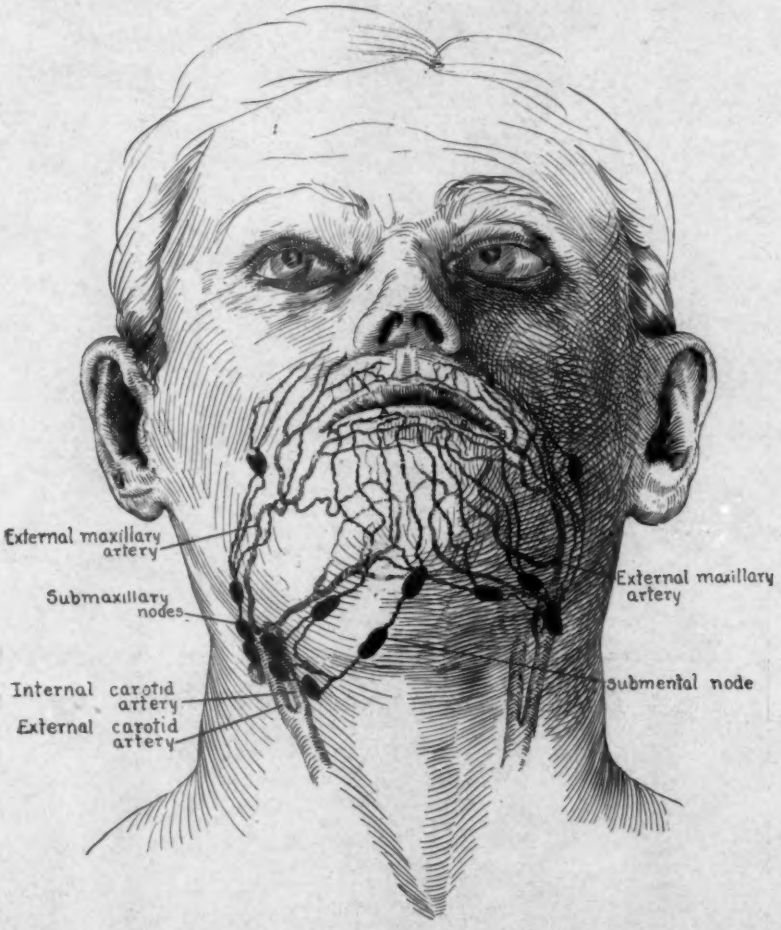

Fig. 1.—Schematic drawing of the lymphatic system of the lower lip. *A* and *B* illustrate the horizontal course of the lymphatics as suggested by Ewing.

it will be a factor in helping many patients to accept the procedure that the majority of competent surgeons believe to be the best.

Since cancer has been recognized, observation has taught that these tumors carry with them, for causes not understood, different grades of malignancy. Formerly, there was no way to differentiate clinically the malignant from the comparatively benign growth. Clinically, the

growths were cancer, and microscopically, they were cancer, but there was not any way of knowing what the behavior of the individual tumor would be.

Not until 1920, was any material progress made in the ability to estimate the degree of malignancy in any cancerous growth. At this time,

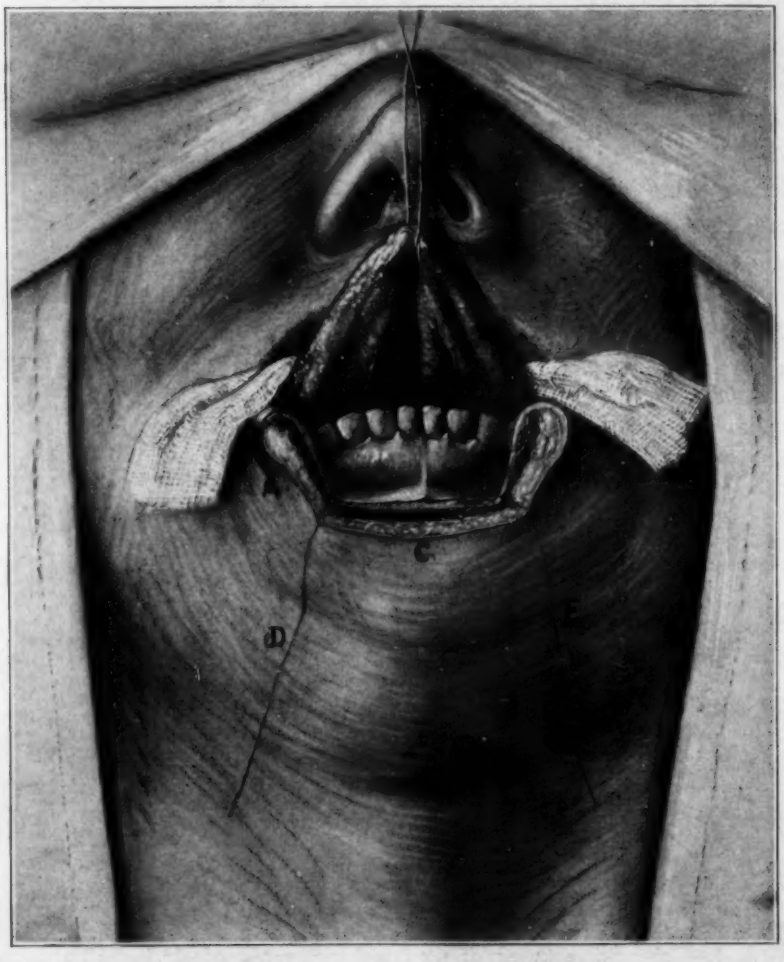

Fig. 2.—First step in the operative procedure. The tumor is removed by three incisions through the entire thickness of the lip. *A* and *B* are vertical incisions on either side of the tumor; *C*, the transverse incision connecting the lower extremities *A* and *B*. In the second step, *D* and *E* indicate the obliquely vertical skin and fat incisions made to mobilize the flap for tissue to form the body for the new lip.

Broders studied a series of cancers of the lip from the immense amount of material at his disposal. His conclusions were that those tumors, the cells of which showed the greatest tendency to differentiation and

keratinization, were least vicious. These, in grade of malignancy, he classed as I. Those tumors, the cells of which did not tend to differentiate, but did tend to infiltration into the deeper structures, he classified as most malignant and put them in grade IV. Grades II and III, in order of malignancy, were placed between grades I and IV.

Fig. 3.—Third step in the operative procedure. With the submental flap dissected free, sufficient skin and fat tissue is obtained to cover the defect, and this exposure makes possible the unusual cervical lymphatic dissection.

Pathologists and surgeons generally have been slow in accepting this classification as of value. Repeated observations on the postoperative courses of those patients on whom the grade was determined have compelled a rather general acceptance of the value of the grading. Some

surgeons hesitate to venture a prognosis as to the outcome of even the most innocent appearing cancerous lesion until its grade is known. A knowledge of the grade of malignancy of a cancer puts one in possession of the most important fact in the determination of whether treatment by surgery or by radiation is the method of choice.

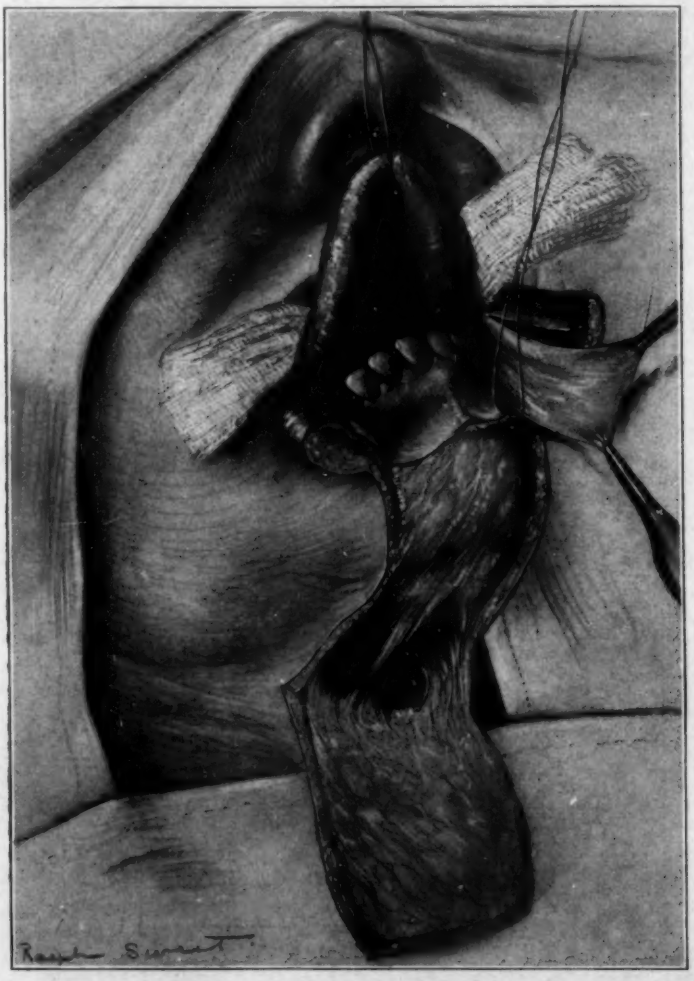

Fig. 4.—Fourth step in the operative procedure showing the method for securing the mucous membrane flaps to cover the buccal portion of the new lip. These flaps must be of sufficient width to permit covering the upper portion of the skin fat flap to form the normal vermilion line.

Judd [4] states that the results obtained at the Mayo Clinic are in accord with the observations of Simmons [5] of Boston, a member of the Cancer Committee appointed by the American College of Surgeons,

5. Simmons, C. C.: Surg. Gynec. Obst. **43**:377, 1926.

in 1922. The investigations of this committee, considering cancer generally, led to the conclusion that "in primary cases without evidence of metastasis surgical treatment offers a thirty-five per cent chance of permanent cure against fifteen percent by irradiation, while in primary cases in which there are clinical signs of metastasis, radium offers no chance of permanent cure and radical surgery not more than 5 per cent."

Fig. 5.—Lower border of the left flap sutured in place; the first suture of the right flap in place showing knots on the inside of the flap.

Simmons' report is further of extreme interest in that it bears out the experience of those who have had the good fortune to have all their operative cases graded. He reported that in cancer of grade I, 68 per cent of permanent cures were effected; of grade II, 21 per cent; of grade III, 6 per cent, and of grade IV, none. These conclusions are in

approximate accord with my observations at the Woodland Clinic. I have never seen a cancer of grade IV that did not show recurrence within a year no matter how innocent clinically the lesion appeared, how radical had been the surgical extirpation, or how intensive the post-operative radiation. Simmons concludes that "the type of operation

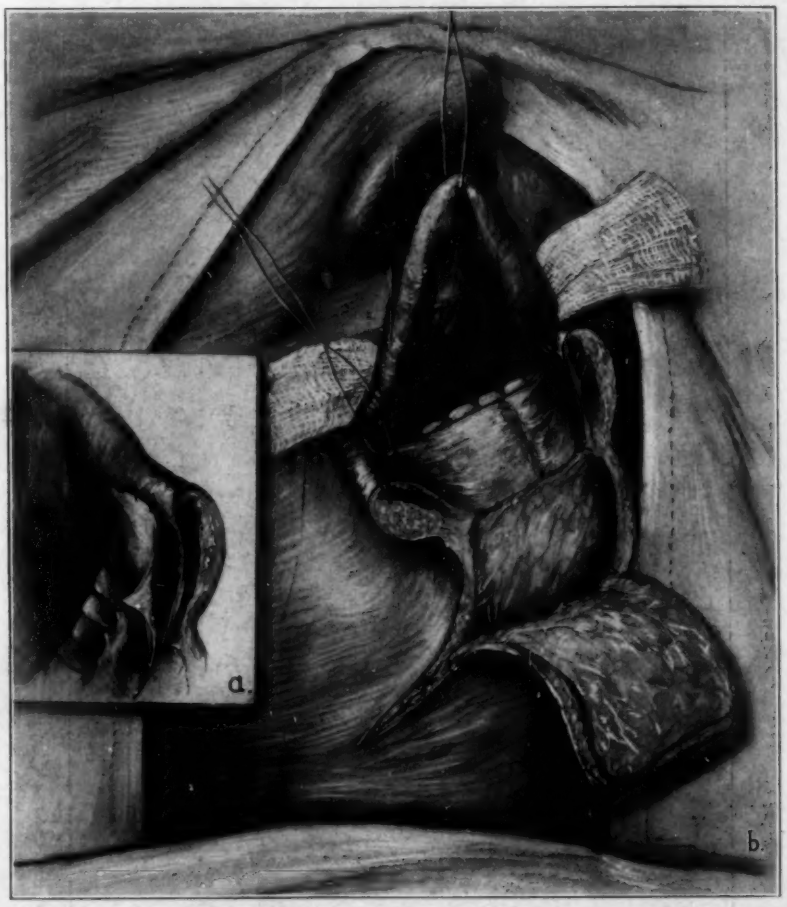

Fig. 6.—Fifth step in operative procedure. Section *b* shows the lateral mucous membrane flaps sutured in a median line and to the mucous membrane edge formed by a transverse incision (*C*, fig. 2). Section *b* illustrates the immediate closure of the buccal mucous membrane defect made in securing the mucous membrane flaps.

performed apparently made little difference. The cases in group I recovered, while those in group IV died."

Applying these observations to the subject under discussion, I believe that in every case of cancer of the lip, irrespective of the apparent grade

of malignancy, a biopsy should be performed. Surgical intervention should not be performed on any tumor of grade IV, and there is serious question whether it is of value in cancers of grade III if there is positive metastasis. Radiation offers as much relief, and by conservative treatment the patient's short span of life will probably be less distressing.

Fig. 7.—Sixth step in the operative procedure showing the skin fat flap suture in place. The buccal mucous membrane flap is sutured to the skin margin, being reflected over the upper border of the skin fat flap to form the labial mucosa and vermilion line.

According to Simmons' statistics, cancers of grades I, II or even III without evidence of metastasis, show a higher percentage of cures by surgical intervention than they do by radiotherapy. As the majority of cancers of the lip fall into these classifications, a discussion is justified

of any surgical technic which will not limit the surgeon in radical extirpation of the tumor and of the distal adjacent lymphatic system, and will at the same time permit him to obtain a better cosmetic effect.

There cannot be an ideal operation for cancer of the lip, for the nature of the lesion compels the sacrifice of all tissue that is under the

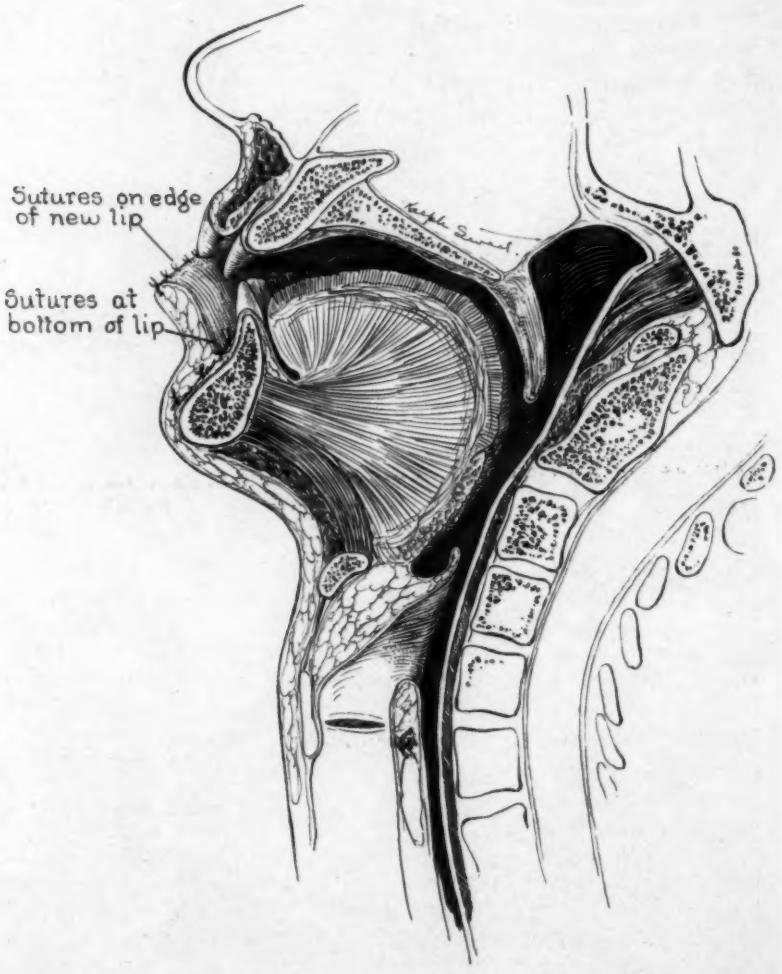

Fig. 8.—Schematic drawing of the sagittal section illustrating the normal sulcus between the reconstructed lip and gums of the lower teeth.

suspicion of involvement. Ewing calls particular attention to the transverse course of the blood and lymph stream in the lips, and emphasizes the relative frequency of local recurrence following the "V"-shaped excision (fig. 1). This circumstance, he believes, may be due to the development of a new tumor by lateral embolism rather than to the

survival of old tumor cells. If his presumption is correct, it is obvious that the patient is in jeopardy from lateral as well as from vertical metastasis, and that any competent surgical procedure must take into account and eliminate this source of probable recurrence as certainly as it does the danger of recurrence from spread through the cervical lymphatic system.

This means that frequently the only chance of obtaining a cure lies in an apparently ruthless sacrifice of the entire lower lip. The ideal surgical procedure would permit this, with a dissection of the gland-bearing fat enbloc, and allow for a satisfactory reconstruction at one operation. No reconstruction can be made entirely satisfactory to the patient, for no plastic lip can have the mobility and expression of the original.

I believe, however, that the technic to be described comes nearer to fulfilling the requirements than any other method I have seen.

Credit is not claimed for originality in any part of the procedure. It is merely a composite technic made up of various steps in other operations.

OPERATIVE TECHNIC

STEP 1.—That portion or all of the lower lip to be sacrificed is excised by three incisions extending through the entire thickness of the lip: a vertical incision on either side of the tumor, with a transverse incision placed at the level of the point of the chin connecting the lower extremities of the vertical incisions (fig. 2).

STEP 2.—From the lower angles of the rectangle formed by the foregoing procedure, bilateral incisions are made through skin and fat running downward and slightly outward for a distance of from 2 to 3 inches (5 to 7.6 cm.). When the skin and fat flap between the two incisions is dissected free, it will be found possible to draw the flap up without tension, a sufficient amount to fill in the deficiency caused by the sacrifice of the lower lip (figs. 2 and 3).

STEP 3.—The submental area is already exposed. The vertical and obliquely vertical incisions previously made on each side permit easy exposure for completion of the usual lymphatic dissection (fig. 3).

STEP 4.—Provision has been made for the skin and fat flap to replace the sacrificed lip. A mucous lining must be supplied for the intra-oral portion of this flap. On each side, such a flap is formed by making two horizontal incisions through the buccal mucosa. The upper incision originates at a point about ¼ inch (0.63 cm.) above the angle of the mouth and extends backward for 2½ inches (6.27 cm.), passing just below the opening of Stenson's duct. The lower incision is parallel to it and of equal length, and originates at a point corresponding to the lower angle of the excised rectangle. These flaps of mucous membrane are dissected up from before backward. It will be found that the flaps can be pulled to the median without tension (fig. 4).

STEP 5.—The extremities of the two mucous membrane flaps are sutured with interrupted, 00 chromic catgut. Similarly, the lower borders of these flaps are sutured to the cut edge of the mucous membrane at the margin of the gum. The denuded area behind the mucous membrane flaps is closed by interrupted chromic catgut sutures, uniting the edge of the mucous membrane above the upper hori-

zontal incision with the edge of the mucous membrane below the lower horizontal incision (figs. 5 and 6).

STEP 6.—The skin and fat flap is then sutured in place by dermal sutures, placed obliquely to distribute such tension as may be present along the entire suture line. The upper border of the united mucous membrane flaps is reflected over the upper border of the skin and fat flap and sutured to the skin line with interrupted chromic catgut sutures to form the vermillon line (fig. 7).

The advantages of this method are: 1. There is nothing in the procedure to cause contractures lessening the size of the mouth. 2. There is nothing to interfere with the most radical extirpation of the tumor with that portion of the lymphatic system which is under suspicion. 3. The entire operation can be completed in one stage. 4. The lower lip does not tend to tighten against the teeth, interfering with a plate, if, as so often happens, one has to be worn. 5. The sulcus in front of the lower incisors is of normal depth (fig. 8).

EXSTROPHY OF THE BLADDER COMPLICATED BY CARCINOMA

E. STARR JUDD, M.D.
AND
HAROLD L. THOMPSON, M.D.
ROCHESTER, MINN.

Carcinoma complicating exstrophy of the bladder is rare; we have noted reports of only nineteen cases in the literature, two of which were reported by Scholl [1] from the Mayo Clinic. We are adding one case (case 1) which has not been reported previously. So far as we know, cure has not been reported following treatment. In two cases at the Mayo Clinic, however, the patients have remained well for three and six and a half years, respectively, following surgical treatment.

EMBRYOLOGY

It is assumed that the fertilized human embryo, by processes of growth and cell division, soon becomes a solid mass of cells, the morula. The peripheral cells of the morula differentiate and thus form a distinct enveloping layer of cuboidal cells [2] (fig. 1 *A*). Vacuoles which appear within the enclosed mass of cells coalesce to form a single cavity within the enveloping layer. This cavity corresponds to the yolk-sac of certain lower species, and hence that name is retained for it. A small mass of cells attached to the interior of the upper pole of the enveloping layer persists as the inner cell mass (fig. 1 *B*). The cells of this mass that are contiguous with the yolk cavity differentiate and proliferate over the inner surface of the enveloping layer to form a complete lining for the yolk-sac. This layer is called the primitive entoderm (fig. 1 *C*). Meanwhile, vacuoles appear also within the inner cell mass, and these coalesce to form the amniotic cavity. This cavity is enclosed by the enveloping layer (fig. 1 *D*); in the floor of this cavity a layer of cells persists, called the embryonic plate or disk. In addition to enclosing the embryo proper, the enveloping layer forms the wall of the amniotic cavity and the outer layer of the wall of the yolk-sac, and thereby envelopes the entire embryo. At this stage of development the embryo consists essentially of the embryonic disk composed of two layers, a layer of ectodermal cells which occupies the floor of the amniotic cavity, and an approximated layer of entodermal cells which is a part of the lining of the yolk-sac.

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1. Scholl, A. J.: The Potential Malignancy in Exstrophy of the Bladder, Ann. Surg. **75**:365, 1922.

2. Bailey, F. R., and Miller, A. M.: Textbook of Embryology, New York, William Wood and Company, 1923, pp. 84-121.

The third primitive layer of cells, the mesoderm, first appears between the ectodermal and entodermal layers of the embryonic disk. As it proliferates, it insinuates itself peripherally between the entoderm of the yolk-sac and the ectoderm of the enveloping layer. Ultimately, it extends to surround also the ectoderm of the amniotic cavity. By internal cleavage, the peripheral portion of the mesoderm is divided into an outer parietal

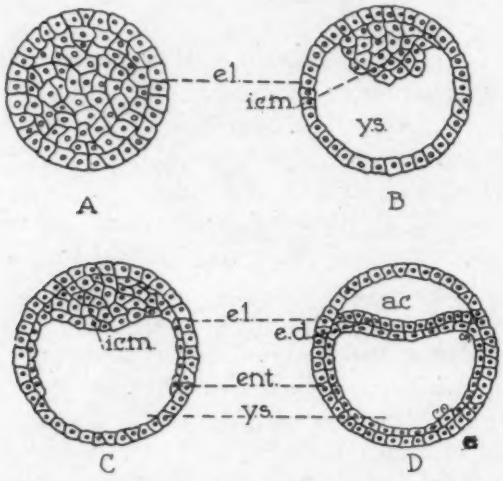

Fig. 1.—*A*, section of morula with enveloping layer (*e.l.*); *B*, section of embryo with yolk-sac (*y.s.*) and inner cells mass (*i.c.m.*); *C*, section of embryo with proliferating entoderm (*ent.*); *D*, section of embryo with embryonic disk (*e.d.*) and amniotic cavity (*a.c.*) (after Bailey and Miller in Textbook of Embryology).

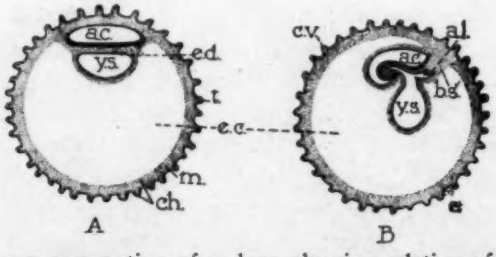

Fig. 2.—*A*, transverse section of embryo showing relation of mesoderm (*m.*) to embryonic disk (*e.d.*), yolk-sac (*y.s.*), amniotic cavity (*a.c.*), and trophoderm (*t.*), extra-embryonic celom, (*e.c.*), chorion, (*ch.*) (after Bailey and Miller). *B*, longitudinal section of embryo with body stalk (*b.s.*), allantois (*al.*) and chronic villi (*c.v.*) (after McMurrich: Development of the Human Body).

layer attached to the interior of the enveloping layer and an inner visceral layer applied to the exterior of the entoderm of the yolk-sac. The space thus formed by the cleavage of the mesoderm is called the extra-embryonic celom. Meanwhile, the enveloping layer becomes dif-

ferentiated into two distinct layers, an outer syncytial and an inner cellular layer, which together comprise the trophoderm, so named from the rôle it plays in the nutrition of the embryo. The trophoderm and the parietal mesoderm together comprise the chorion [2] (fig. 2 *A*). As a result of the enlargement of the extra-embryonic celom, the embryo proper becomes separated increasingly from the chorion and remains attached to it only by a cord of mesoderm known as the body stalk [3] (fig. 2 *B*). The youngest human embryos which have been observed are at this stage of development.

While the formation of the primitive embryonic layers proceeds in this way, a linear opacity, the primitive streak, gradually becomes manifest on the surface of the embryonic disk. Anterior to the primitive streak, an opaque band, the axial line, appears [2] (fig. 3 *A*). In a cross-section of the latter, it is seen to be composed of a local proliferation of cells of all the primitive layers. As mentioned, the proliferating mesoderm insinuates itself between the ectoderm and entoderm, and the peripheral portion undergoes internal cleavage. In sections, the mesoderm is seen to be divided by a shallow longitudinal groove into the peripheral cleft portion and a paramesial solid portion. The surface of the paramesial solid portion of the mesoderm becomes segmented transversely, forming somites or body segments. A longitudinal groove which appears in the ectoderm of the axial line gradually deepens to form the neural groove. By subsequent fusion of the margins over the trough of this groove, the neural tube is formed [2] (fig. 3 *B*).

In its earlier stages, the embryonic disk may be conceived of as floating on the upper portion of the yolk-sac. Subsequently, a furrow develops at the periphery of the disk and deepens progressively until the opposing edges approximate and fuse ventrally in the median plane, thus giving cylindric form to the embryo [3] (fig. 4 *C*). A portion of the yolk-sac is thereby constricted off and enclosed within the embryo as the primitive digestive tract, while by the same process the amniotic cavity is extended completely around the embryo and forms a constriction about the body stalk which thus completes the formation of the umbilical cord. The anterior and posterior extremities of the embryo meanwhile fold ventrally on the body, forming respectively the head and tail folds [3] (fig. 4 *D*). The embryo at this stage is suspended in the amniotic cavity by the umbilical cord.

Early in the history of the yolk-sac, the allantois originates from it as an evagination [4] (fig. 5). Its growth proceeds through the body stalk

3. McMurrich, J. P.: Development of the Human Body, ed. 7, Philadelphia, P. Blakiston's Son & Co., 1923, p. 41.

4. Lewis, F. T.: The Early Development of the Entodermal Tract and the Formation of its Subdivisions, in Keibel and Mall: Manual of Human Embryology, Philadelphia, J. P. Lippincott Co., 1912, vol. 2, p. 295.

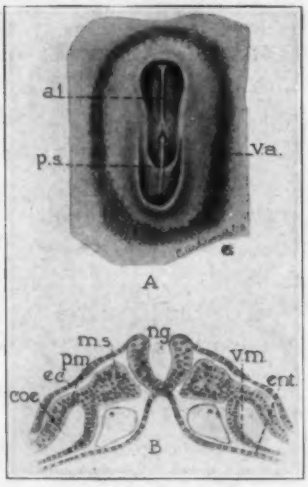

Fig. 3.—*A*, germinal disk with primitive streak (*p.s.*), axillary line (*a.l.*) and *v.a.*, vascular area. *B*, transverse section of germinal disk with neural groove (*n.g.*) and mesoderm between ectoderm (*e.c.*) and entoderm (*ent.*) which is divided by a longitudinal groove into a paramesial solid portion forming the mesodermic somites (*m.s.*) and a peripheral portion which is cleft by the celom (*coe.*) forming parietal mesoderm (*p.m.*) and viseral mesoderm (*v.m.*) (after Bailey and Miller).

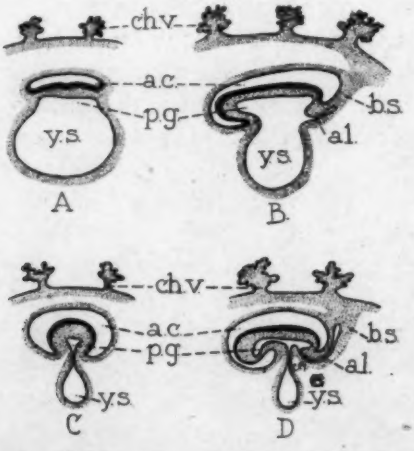

Fig. 4.—Sections of embryo with constriction between embryo and yolk-sac. *A* and *C*, transverse sections; *B* and *D*, longitudinal sections. *ch.v.*, chorionic villi; *a.c.*, amniotic cavity; *p.g.*, primitive gut; *y.s.*, yolk-sac; *al.*, allantois; *b.s.*, body stalk (after McMurrich).

and ultimately reaches the placenta [4] (fig. 6). The foregut and hindgut originate also as evaginations of the yolk-sac. The caudal portion of the hindgut expands as the cloaca, the interior of which communicates directly with that of the hindgut and that of the allantois. In man the cloaca is a temporary structure, but in the amphibia, reptiles and birds it is permanent.

During the formation of the tail-fold, the ventral portion of the cloacal entoderm becomes approximated to and fuses with the ventral ectoderm to form the cloacal membrane [5] (fig. 7 *A*). Through increase

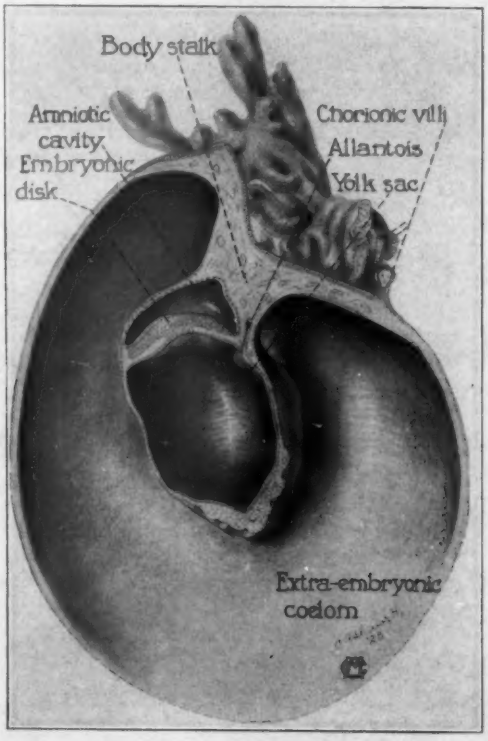

Fig. 5.—Median longitudinal section of Minot's embryo (after Lewis in Keibel and Mall: Manual of Human Embryology).

in the surrounding mesoderm, this membrane becomes folded into the substance of the embryo so that seen from without it lies at the bottom of a shallow groove situated at the ventrocaudal region of the body [6] (fig. 7 *B*).

5. Felix, W.: The Development of the Urinogenital Organs, in Keibel and Mall: Manual of Human Embryology, Philadelphia, J. P. Lippincott Co., 1912, vol. 2, p. 869. Keibel, F.: Zur Entwickelungsgeschichte der Harnblase, Anat. Anz. **6**:186, 1891; Zur Entwickelungsgeschichte des menschlichen Urogenital-apparates, Arch. f. Anat. u. Entw., 1896, p. 55.

6. Footnote 5 (second and third references).

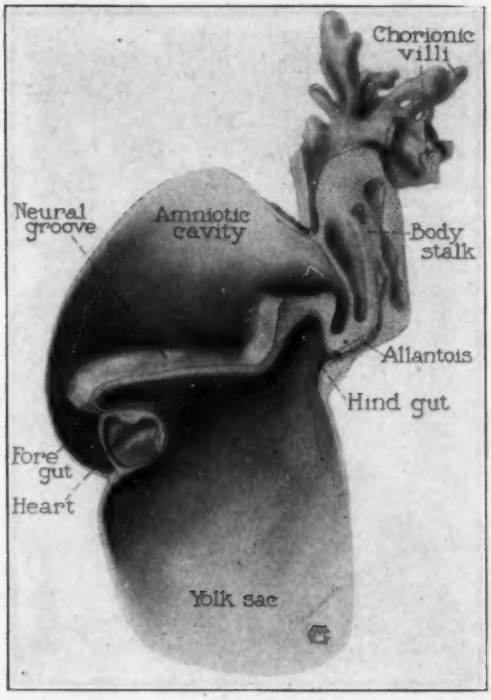

Fig. 6.—Median longitudinal section of Mall's series 391 (after Lewis in Keibel and Mall: Manual of Human Embryology).

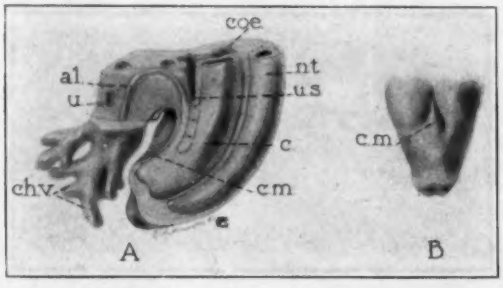

Fig. 7.—*A*, median longitudinal section of model of caudal region of embryo from His' collection in which gradual separation of the bladder from the rectum is shown diagramatically by the series of dotted lines (after Keibel and Felix in Keibel and Mall: Manual of Human Embryology); *coe.*, celom; *n.t.*, neural tube; *u.s.*, urorectal septum; *al.*, allantois; *u.*, umbilicus; *c.*, cloaca; *c.m.*, cloacal membrane; *ch.v.*, chorionic villi. *B*, ventral aspect of model of caudal region of embryo from His' collection in which cloacal membrane (*c.m.*) occupies the bottom of a groove (after Keibel).

The primary excretory duct, which is formed by the fusion of the tubules of the pronephros, grows downward and joins the ventral portion of the cloaca. Later, it serves as the excretory duct of the mesonephros, at which time it is known as the wolffian duct. From this, the anlage of the permanent kidney is formed.

Both the bladder and the rectum are formed from the cloaca by the downward extension of the fold of tissue between the allantois and the hindgut. The partition thus formed is known as the urorectal septum [5] (fig. 7 *A*). The ventral portion of the cloaca thus divided is the vesico-urethral anlage, and the dorsal portion is the rectal anlage. Fusion of the urorectal septum with the cloacal membrane divides the latter into an anterior urogenital and a posterior anal membrane. The cephalad portion of the vesico-urethral anlage retains its attachment to the allantois. The bladder finally is formed by the enlargement and cephalad growth of the vesico-urethral primordium, the caudal portion remaining narrow as the urethra. By gradual absorption of the lower portion of the wolffian duct by the vesico-urethral anlage, the ureter comes to open into it. Gradually, the urethral orifice is shifted to its final position at a point lateral to and above the orifice of the wolffian duct. Meanwhile, the allantois undergoes retrogressive changes by which ultimately it is reduced to a solid fibrous cord which extends from the apex of the bladder to the umbilicus as the urachus. The anal opening is formed by perforation of the anal membrane. Thus it is seen that the bladder and rectum are derived from a common embryonic structure, the cloaca.

HISTOLOGY

The histologic structure of the bladder in persons with exstrophy usually is unlike that of the normal bladder. The lining epithelium of the normal bladder characteristically is of the transitional type. Statements to the effect that glands in the mucosa of the normal bladder do not exist appear in some authoritative works on anatomy (Piersol [7]) and histology (Bohm, von Davidoff and Huber [8]). In others, it is stated that usually in the mucosa about the urethral orifice and occasionally also in the fundus of the bladder mucous follicles are present which have been described as glands by several observers, including Kölliker,[9] von

7. Piersol, G. A.: Human Anatomy, Philadelphia, J. P. Lippincott & Co., 1923, vol. 2, p. 1909.

8. Bohm, A. A.; von Davidoff, M., and Huber, G. C.: The Pelvis of the Kidney, Ureter and Bladder, in Textbook of Histology, Philadelphia, W. B. Saunders Co., 1916, p. 337.

9. Kölliker, A.: Physiological Remarks: Development of the Urinary Organs, in Manual of Human Histology, London, The Sydenham Society, 1854, vol. 2, p. 208.

Brunn [10] and Albarran.[11] Bridoux [12] pointed out that while many observers agree on the existence of these glands their descriptions of them are not in accord. It appears, therefore, that the question of the existence of glands in the mucosa of the normally developed bladder remains an open one.

In reported histologic studies of exstrophy of the bladder, on the other hand, glands have been observed consistently. Thus, glandular tissue was present in each of a total of eighteen cases of exstrophy of the bladder examined by Shattock,[13] Enderlen [14] and Scholl.[1] The ages of their patients ranged from a few months to 77 years. In the cases of two new-born infants, on the other hand, Enderlen found normal transitional epithelium but did not find glands, and Formiggini [15] found cystic cavities but did not find glands. Enderlen concluded that glandular tissue normally is present in cases of exstrophy of the bladder in which the patient is more than a few months of age.

The literature on the histogenesis of glandular mucosa in exstrophy of the bladder has been reviewed by Formiggini. Enderlen interpreted its presence as a result of metaplasia following a functional change in the mucosa induced by mechanical irritation, by drying and the decomposition of urine. Ehrich [16] expressed the belief that the glands develop from a displaced or undeveloped spur of cloacal entoderm whereby embryonic epithelium of the dorsal or rectal wall of the cloaca is included in the ventral or vesical wall. Reichel [17] proposed the explanation that the glands result from failure of cloacal epithelium to be differentiated normally as vesicle epithelium and that thus it contains glands like those of the rectal mucosa. Righetti [17] studied histologically the rectum of a patient with exstrophy of the bladder and found that the mucosa of the rectum in certain areas contained epithelium of the vesical type and in other regions undifferentiated epithelium, which he interpreted as evolv-

10. Von Brunn, A.: Ueber drüsenähnliche Bildungen in der Schleimhaut des Nierenbeckens, des Ureters und der Harnblase beim Menschen, Arch. f. mikr. Anat. **41**:294, 1893.

11. Albarran, J.: Les tumeurs de la vessie, Paris, G. Steinheil, 1892, pp. 494.

12. Bridoux, Henri: A Case of Adenoma of the Bladder with Remarks on the Pathology of the Affection, Am. J. Urol. **9**:514, 1913.

13. Shattock, S. G.: Specimens of Epispadias and Extroversio Vesicae Showing an Attachment of the Muscular Wall of the Bladder to the Back of the Pubic Bones, Tr. Path. Soc., London, 1894, vol. 45, p. 117.

14. Enderlen, E.: Zur Histologie der Schleimhaut der ektopierten Blase, Verhandl. d. deutsch. path. Gesellsch. **7**:167, 1904.

15. Formiggini, Benedetto: Contributo allo studio istologico della mucosa vesicale extrofica, Riforma med. **36**:252, 1920.

16. Ehrich, E.: Gallertkrebs der ekstrophierten Harnblase, Beitr. z. klin. Chir. **30**:581, 1901.

17. Quoted by Formiggini.

ing at certain points toward the vesical type and at others toward the intestinal type. Remedi [17] declared that certain glands derived from substrata completely foreign to either bladder or rectum become abnormal in early periods of life for unknown reasons and persist throughout life. Formiggini concluded that while these theories are seductive, there is as yet no proof for the correctness of any of them, and that Enderlen's theory might be acceptable if it were based on observations in more than two cases.

ETIOLOGY

The ultimate cause of exstrophy of the bladder is not known. According to Young,[18] the existing theories collectively propose that this anomaly results from: (1) mechanical rupture; (2) pathologic lesions, or (3) defective embryonic development. The basis of the first conception is the assumption that the bladder ruptures from occlusion of the urethra. Hutchins and Hutchins [19] credited the origin of this conception to Bon and Duncan.[20] The adherents include Mueller, Rokitansky, Winckel, Brandl and Tiersch. Young pointed out that it fails to explain the associated epispadius and ununited pubes, and for these reasons the theory no longer has any proponents of note. Velpeau is said to have expounded the second hypothesis in which exstrophy of the bladder is interpreted as resulting from ulceration of the lower anterior abdominal wall, including the dorsal surface of the penis in the male, followed by the formation of adhesions. This theory does not explain the constant anatomic relations observed in this condition, and for this reason it likewise has been discarded. The adherents of the third hypothesis, that exstrophy is the final result of defective embryonic development of the bladder, include St. Hilaire, Meckel, Jaimain, Vialleton, Keibel, Gilis and others.

There are several modifications of the third hypothesis. Jaimain proposed that exstrophy of the bladder results from malunion in the median plane of the abdominal wall similar to that of the face in harelip. Kelly and Burnam [21] supported this view. Young expressed the belief, however, that this cannot be the cause, as the entodermal cavity from which the bladder is derived is closed from its beginning. Vialleton assumed that the cloacal membrane extends forward to an abnormal degree as a result of a primary defect in the abdominal wall, and that exstrophy results from the natural perforation of this mem-

18. Young, H. H.: Practice of Urology, Philadelphia, W. B. Saunders Company, 1926, vol. 1, p. 538; vol. 2, p. 63.

19. Hutchins, E. H., and Hutchins, A. F.: Exstrophy of Bladder with Successful Transplantation of Ureters into Rectum, Surg. Gynec. Obst. **36**:731, 1923.

20. Bon and Duncan, A., quoted by Hutchins and Hutchins.

21. Kelly, H. A., and Burnam, C. F.: Diseases of the Kidney, Ureter and Bladder, New York, D. Appleton & Company, 1914, vol. 2, p. 385.

brane. Von Geldern [22] accepted the view of Johnston [23] that the cause of exstrophy of the bladder complicated by intestinal fistula is early rupture of the cloacal membrane with arrested development of the urorectal septum. He suggested also that disturbance of chemical balance underlies these factors.

Young considered Keibel's theory the most tenable. Keibel demonstrated that the cloacal membrane arises from the caudal portion of the primitive streak, in some cases extending beyond its usual anterior limit on to the body stalk and thereby covering the region which gives rise to the genital papilla and a portion of the lower abdominal wall. He considered the primitive streak of mammals as the equivalent of the blastophore of lower vertebrates and expressed the belief that exstrophy of the bladder results, therefore, from persistent open blastophore.

Gilis agreed with Keibel that exstrophy of the bladder results from the perforation of the cephalad extension of the cloacal membrane, but he did not agree that it has the phylogenetic significance attributed to it by Keibel. Gilis added what seems to be a significant point, that normally the infra-umbilical region is strengthened by the medial growth of the protovertebral laminae of mesoderm which give rise to the abdominal muscles and fascia. Exstrophy of the bladder may result, therefore, from failure of these muscles in their development sufficiently to reinforce the cloacal membrane.

PATHOLOGY

Carcinoma is a rare complication of exstrophy of the bladder. Usually in persons with exstrophy of the bladder there are varying degrees of local inflammation, the result of mechanical and chemical irritation and infection. Associated ascending infection is common, and death usually is caused by toxemia of infection or of renal insufficiency. We have noted reports in the literature of nineteen cases of carcinoma complicating exstrophy of the bladder. Fourteen of these were of adenocarcinomas and two were of squamous-cell carcinomas; a histologic report was not included in three cases.

Although adenocarcinoma is of comparatively rare occurrence in the normal bladder, it is the type which most commonly occurs in exstrophy of the bladder. According to Young, adenocarcinoma comprises not more than 1 or 2 per cent of all the tumors of the bladder. In 369 tumors analyzed by Gardner,[24] four were diagnosed adenocar-

22. Von Geldern, C. E.: The Etiology of Exstrophy of the Bladder, Arch. Surg. **8**:61 (part 1) (Jan.) 1924.

23. Johnston, T. B., quoted by von Geldern.

24. Gardner, J. A.: Clinical Results in Operations on Tumors of the Bladder by Various Operators for the Last Fifteen Years (A Review of 1,702 Cases), Tr. Am. Urol. A., 1915, vol. 9, p. 165.

cinoma. There were nineteen (2.19 per cent) adenocarcinomas in 867 tumors of the normally developed bladder at the Mayo Clinic.

The mode of origin of adenocarcinoma in the normally developed bladder is not known. Young observed that the glands which are present in the mucosa of the normal bladder resemble the prostate and the glands of the prostatic urethra, and also that adenocarcinoma of the bladder commonly resembles carcinoma of the prostate. Verhoogan [25] added that adenocarcinoma of the bladder is encountered almost exclusively in the male. In contrast, the adenocarcinoma in exstrophy of the bladder usually resemble adenocarcinoma of the bowel; a considerable proportion occurs in females. Enderlen suggested that adenocarcinoma in exstrophy of the bladder results from metaplasia. This hypothesis is based on his conclusion that transitional epithelium is "normal" in exstrophy of the bladder since he found it in those of two new-born infants. Scholl expressed the belief that adenocarcinoma in exstrophy of the bladder results from a combination of metaplasia and hyperplasia. As we have pointed out, the presence of glandular tissue in most persons with exstrophy of the bladder in whom histologic studies have been made indicates that it is present normally.

From the embryologic considerations outlined, however, it seems logical to assume that the presence of glandular tissue in the bladder is a result of cell inclusion. The fact that both the bladder and the rectum are derived from the embryonic cloaca and the fact that exstrophy of the bladder is a congenital defect make this at least a reasonable assumption. Ehrich expressed this opinion in the statement that the bladder and intestines come from the same source, and that in their abnormal situation the tissues in exstrophy of the bladder have not the stimulus to assume normal transitional epithelium but retain that of the intestine. The occurrence of intestinal fistula complicating exstrophy of the bladder as in Keith's,[26] Hache's [27] and von Geldern's cases further demonstrates the close relation of the intestine to the bladder developmentally. Any attempt to explain the occurrence of adenocarcinoma in exstrophy of the bladder at least must consider these factors.

REPORT OF TWO CASES

CASE 1.—A woman, aged 38, came to the Mayo Clinic, Feb. 3, 1925, because of congenital deformity of the bladder. The deformity had caused little inconvenience until two years previously. As a child she had taken an active part in all games with other children; she had ridden a bicycle, and up to the last two years she had

25. Verhoogan, J.: Neoplasmes de la vessie, Encycl. franç. d'urol. **4**:425, 1921.

26. Keith, A.: Malformations of the Hind End of the Body, Brit. M. J. **2**: 1857, 1908.

27. Hache, Maurice: Pathogénie et variétés de l'exstrophie de la vessie, Rev. de chir. **8**:218, 1888.

attended dances and other social functions. She had never been able to control the flow of urine and had always worn napkins to collect it. The urine contained slight amounts of blood. Menstruation began at 14; the periods always had been regular but were associated with considerable pain. Two years before admission, local burning and aching appeared; this was increased on walking. The amount of

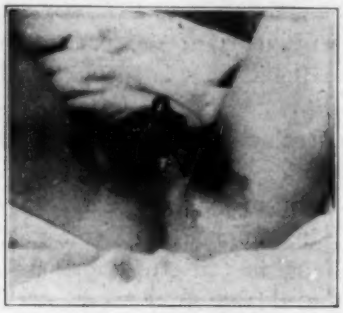

Fig. 8 (case 1).—Exstrophy of the bladder complicated by carcinoma.

Fig. 9 (case 1).—Excised bladder.

blood in the urine had increased. The bladder gradually had enlarged and usually was covered with slimy material with a foul odor. The patient had lost 20 pounds (9 Kg.) during the last two years.

The general examination gave negative results, except that the umbilicus was absent and a mass about 8 cm. in diameter on a broad pedicle projected from between the widely separated labia minora (fig. 8). The mass was covered with the tenacious mucoid discharge. It was extremely tender and bled on slight manipulation. Urine was seen to trickle from two points and menstrual blood

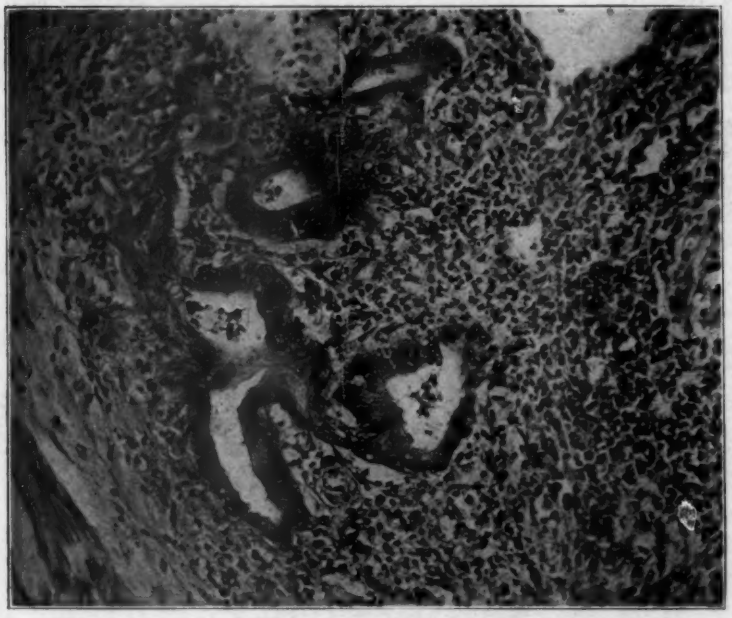

Fig. 10 (case 1).—Adenocarcinoma of the bladder; × 150.

Fig. 11 (case 1).—Adenocarcinoma of the bladder; × 350.

issued from a point posterior to the mass. The inguinal lymph nodes were enlarged. The urine contained albumin, blood and pus. Roentgenograms revealed congenital absence of the pubic bones. On the basis of these observations, a diagnosis of carcinoma complicating exstrophy of the bladder was made and was confirmed by biopsy.

The entire bladder was excised with the actual cautery (fig. 9). The right ureter appeared normal; fluid under pressure spurted from the left ureter, suggesting hydronephrosis. The ureters were drawn outside the wound and small retention catheters inserted. The pathologic diagnosis was adenocarcinoma of the bladder (figs. 10 and 11).

Fig. 12 (case 2).—Exstrophy of the bladder complicated by carcinoma.

The patient was advised to return for observation but did not do so until Feb. 1, 1928. At that time, her general condition was greatly improved. She had gained 40 pounds (18.1 Kg.). Examination revealed prolapse of the uterus; urine was not coming from the left ureter. There was no evidence of metastasis.

CASE 2.—A man, aged 48, came to the Mayo Clinic, Oct. 20, 1921, complaining of hemorrhages from the bladder. Exstrophy of the bladder had been present at birth. When he was 19, two plastic operations had been performed which were partially successful in enclosing the bladder. In 1920, he had had a mild stroke which temporarily affected the right side of the face and the right leg. In April, June and October of 1921 he had had hemorrhages from the bladder, on each occasion losing about a half pint of blood. He had lost 8 pounds (3.6 Kg.) since the first hemorrhage.

Examination revealed the exstrophy of the bladder to be partially covered by transplanted tissue (fig. 12). The mucosa of the bladder was hypertrophied, and it bled on slight handling. Bilateral inguinal hernia was present. The systolic blood pressure was 180 and the diastolic, 95.

The urine contained blood and albumin. The hemoglobin was 48 per cent, and the blood urea was 32 mg. for each hundred cubic centimeters. Roentgenograms revealed absence of the pubic bones. Dye was excreted normally from both ureters. The condition was diagnosed as carcinoma complicating exstrophy of the bladder and was confirmed by biopsy (fig. 13).

The mucosa of the bladder was completely excised. The thickened and dilated ureters were not disturbed. Radium was applied. The pathologist reported

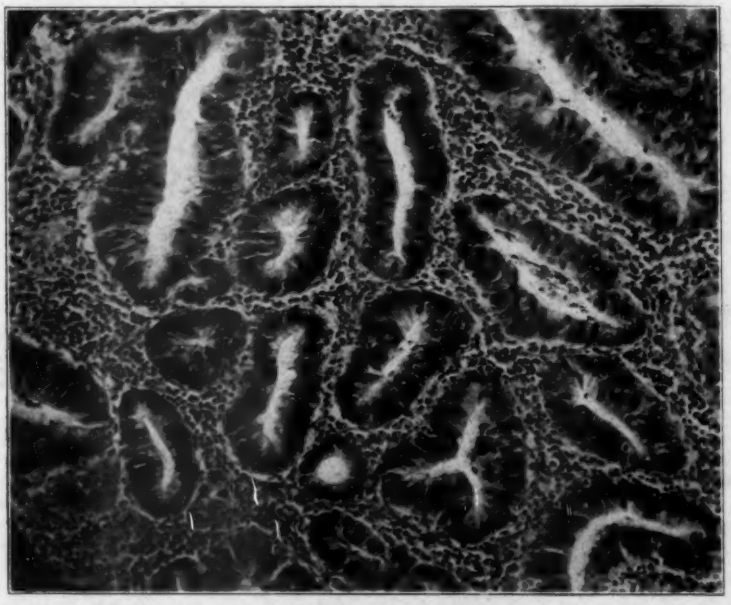

Fig. 13 (case 2).—Adenocarcinoma of the bladder.

adenocarcinoma. On April 18, 1928, the patient reported that his general health was good.

(This case was reported previously by Scholl.)

COMMENT

Of the twenty cases reported, including the ones in the table, twelve occurred in men, seven in women, and in one case the sex was not mentioned. Two occurred in the third decade, five in the fourth, nine in the fifth, three in the sixth and one in the seventh. As stated, adenocarcinoma was reported in fifteen cases, squamous-cell carcinoma in two, and in three cases a histologic report was not made.

Surgical treatment was employed in ten of the twenty cases. In three, simple extirpation of the bladder was performed. In one case

ABSTRACT OF CASES

Case	Year	Author	Sex	Age	Lesion	Treatment	Comment
1	1895	Bergenhem (quoted by Lecene and Hovelacque)	M	35	Adenocarcinoma	Transplantation of ureters; extirpation	Working 6 mos. after operation
2	1901	Ehrich (Beitr. z. klin. chir. **30**: 581, 1901)	F	44	Adenocarcinoma	Resection and transplantation of ureters and bladder mucosa	Died eighth day from ascending infection and uremia
3	1904	Enderlen (Verhandl. d. deutsch. path. Gesellsch. **7**: 167, 1904)	F	38	Adenocarcinoma	Radiotherapy	Not benefited
4	1905	Lampe (Verhandl. d. deutsch. Gesellsch. f. Chir. **34**: 226, 1905)	M	48	Squamous-cell carcinoma	Sonnenberg operation	Recovered; not traced
5	1906	Von Eiselsberg (Wien. klin. Wchnschr. **19**: 548, 1906)	F	51	Adenocarcinoma	Extirpation	Living 15 mos. after operation
6	1909	Sargent (Brit. J. Child. Dis. **6**: 115, 1909)	M	39	Clinically carcinoma	None	Not traced
7	1910	Wagner (Deutsche Ztschr. f. Chir. **104**: 330, 1910)	M	49	Adenocarcinoma	Biopsy only	Not traced
8	1910	Hager (München. med. Wchnschr. **57**: 2300, 1910)	M	66	Adenocarcinoma	Symptomatic	Died from cachexia
9	1910	Schloffer (Wien. klin. Wchnschr. **23**: 1158, 1910)	M	46	Carcinoma	Curettage	Result not mentioned
10	1912	Lecene and Hovelacque (J. d'urol. méd. et chir. **1**: 493, 1912)	M	48	Adenocarcinoma	Symptomatic	Died from cachexia
11	1912	Lecene and Hovelacque	F	57	Squamous-cell carcinoma	Previous nephrectomy	Died from cachexia
12	1914	Hunner (In Kelly and Burnam: Diseases of the Kidney, Ureter and Bladder, New York, D. Appleton & Co., 1914, vol. 2, p. 389)	F	26	Adenocarcinoma	Not mentioned	Result not mentioned
13	1918	Geraghty (In Cabot: Modern Urology, Philadelphia, Lea & Febiger, 1918, vol. 2, p. 208)	?	48	Adenocarcinoma	Not mentioned	Result not mentioned
14	1921	Lower (Ann. Surg. **73**: 354, 1921)	M	50	Clinically carcinoma	Transplantation of ureters; excision	Result not mentioned
15	1922	Scholl (Ann. Surg. **75**: 365, 1922)	F	23	Adenocarcinoma	Transplantation of ureters; excision	Died 2 years after operation from metastasis
16	1922	Scholl	M	48	Adenocarcinoma	Excision; radium	Reported well 6 years and 6 mos. later
17	1922	Dupont (J. d'urol. méd. et chir. **13**: 433, 1922)	M	38	Adenocarcinoma	Exclusion of rectum	Died 2 days after operation
18	1924	Murphy (J. A. M. A. **82**: 784 [March 8] 1924)	M	49	Adenocarcinoma	Radium emanation	Examined after 14 mos.
19	1925	McCarthy and Klemperer (J. Urol. **14**: 419, 1925),	M	47	Adenocarcinoma	Diathermy; ureterostomy; nephrectomy and cystectomy	Convalescent at time of report
20	1928	Judd and Thompson	F	38	Adenocarcinoma	Cautery excision of bladder	Well 3 years after operation

(reported by Scholl), transplantation of the ureters by the Mayo[28] method preceded removal of the bladder. The patient died two years after the operation from metastasis. In the two cases reported here, the patients are alive and well three and six and a half years, respectively, after operation. Von Eiselsberg's patient was living and well fifteen months after extirpation of the bladder. In three other cases transplantation of the ureters into the colon was performed. One of these patients died eight days later from uremia following ascending renal infection. In the other two cases, resection of the bladder was performed secondarily. In one case, the patient was well and working six months after operation; in the other case, the result was not stated. In one case nephrectomy, abdominal ureterectomy and cystectomy were performed; the patients were recovering from these operations at the time the report was made. In one case the Sonnenberg operation was performed; the patient recovered but was not traced afterward. In one case exclusion of the rectum was attempted, from which the patient died. Radium was applied in two cases as the only treatment; one of the patients was well after fourteen months, but the other was not improved. Six patients either did not receive treatment or were given symptomatic treatment only, and in two cases the treatment was not mentioned. Three of the six patients died from cachexia; two were not treated because of bad prognosis, and the result was not stated with regard to the other.

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28. Mayo, C. H.: Exstrophy of the Bladder and its Treatment, J. A. M. A. **69**:2079 (Dec. 22) 1917; Exstrophy of the Bladder, Contribution to Medical and Biologic Research, New York, Paul B. Hoeber, 1920, p. 1095; The Formation of a Cloaca in the Treatment of Exstrophy of the Bladder, Surg. Clin. N. Amer. **1**:1257, 1921. Mayo, C. H., and Hendricks, W. A.: Exstrophy of the Bladder, Surg. Gynec. Obst. **43**:129, 1926. Mayo, C. H., and Walters, Waltman: Transplantation of Ureters into Rectum: End-Results in Thirty-Five Cases of Exstrophy of Bladder, J. A. M. A. **82**:624 (Feb. 3) 1924.

THE RELATIVE MECHANICAL STRENGTH OF ENTEROSTOMIES PERFORMED WITH AND WITHOUT CLAMPS

AN EXPERIMENTAL STUDY *

R. A. CUTTING, M.D., PH.D.
NEW ORLEANS

Certainly many, perhaps most, of those members of the medical profession whose interest leans toward surgery, especially abdominal surgery, have a fairly well defined mental reaction either in favor of or opposed to the use of clamps in intestinal work. On the one hand, there are those who believe that the use of clamps is a pernicious practice and one which should be generally abandoned, while, on the other hand, there are those who feel that for one reason or another the technic in which clamps are used is preferable to a clampless method; still others believe that the use of clamps should perhaps be confined to the occasional or relatively unskilful operator, while a clampless technic should be the goal of the finished surgeon.

Though there have appeared in the literature over a number of years various studies which have pointed out some of the possible unfavorable sequelae of the use of clamps in intestinal operations, especially the occurrence of hematomas and postoperative ulceration, direct experimental attacks on some of the other aspects of the problem, especially the relative mechanical strength of enterostomy wounds made with and without clamps, have not, to my knowledge, been subjected to systematic investigation.

The experiments to be reported in this paper were undertaken primarily to elucidate the question of mechanical strength, but an attempt was made at the same time to observe and record a few other phenomena which might present some bearing on the general question of the advisability or inadvisability of the use of clamps in intestinal operations.

TECHNIC EMPLOYED

Recording Pressure.—It has been assumed, for purposes of the present investigation, that the pressure required to burst the intestinal wall is an accurate measure of the mechanical strength of the latter, and for recording bursting pressures the mercury manometer has been accepted as the standard of measurement.

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* From the Department of Surgery, Tulane University of Louisiana School of Medicine.

Preliminary tests with sections of intestine removed from dogs recently killed in the course of other experiments showed that it might be necessary in the course of these experiments to record pressures well over 1,000 mm. of mercury; accordingly, a 4 foot manometer was constructed by bending glass tubing in the shape of a *U*, mounting it on a wooden support, as illustrated in figure 1, and filling it to a depth of 2 feet (61 cm.) with metallic mercury. To one arm of the manometer was attached a piece of fairly stiff-walled rubber tubing, about 3 feet (91 cm.) long, and to the other end of the tubing

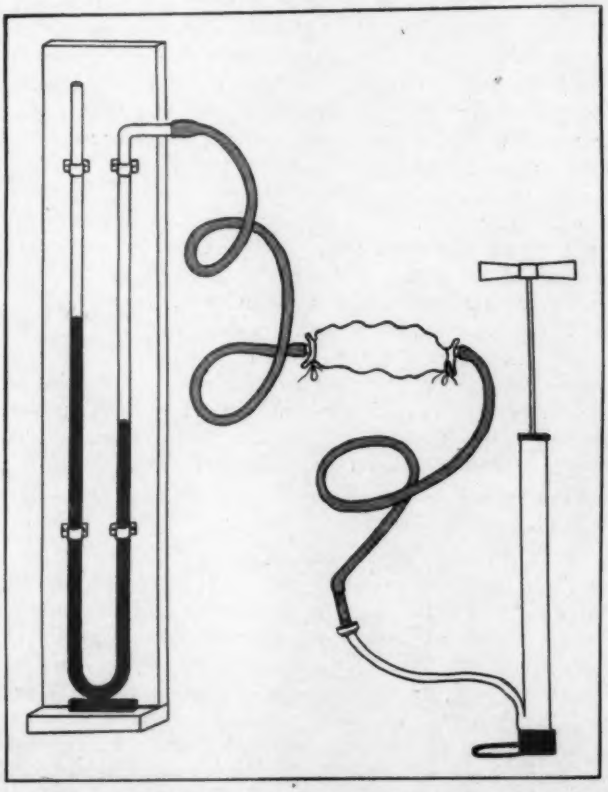

Fig. 1.—Apparatus used for introducing air pressure into segments of intestine and for measuring the pressure required to burst these segments. An automobile tire pump forces air through the valve stem of an inner tube with its contained air valve and thence through rubber tubing to the segment of intestine; the other end of the intestinal lumen connects by rubber tubing with one arm of a large mercury manometer.

was fitted a short piece of glass tubing over which a segment of intestine might be slipped and subsequently tied. Air pressure was introduced into the other end of the segment of intestine by means of an automobile tire pump connected by means of another length of rubber tubing and a glass end piece over which the free end of the intestinal segment might be fitted and tied as before. As a connection between the regular screw cap of the tire pump and

the rubber tubing in the latter part of the apparatus, the stem of the inner tube of an automobile with its contained air valve was introduced, so as to prevent reflux of air from the system to the pump, once the plunger of the latter had initiated its action. Such an apparatus, though somewhat ungainly in size, was found not to have an undue reserve capacity in cases in which the bursting pressure required was near normal, and by the exercise of a little care it was found feasible to increase the pressure in the system up to the point of rupture of segments of intestine with a fair degree of rapidity and without causing much oscillation in the columns of mercury. It was considered that the bursting pressure of a segment of intestine might vary with the interval of time during which it was required to withstand the development of the pressure; accordingly, when the ruptures were performed, air was forced into the system as rapidly as could be done without inducing oscillation of the mercury columns and as steadily as possible. The intestinal wall was required to withstand pressure for about ten seconds under these circumstances, and the pressure at which the rupture occurred could be determined with an accuracy well within 5 mm.; an attempt was not made, however, to estimate more accurately than 5 mm., since the pressure magnitudes in every case brought the margin of error under these conditions well within an experimental error of 5 per cent, which could hardly be considered of serious moment in a consideration of end-results under the contemplated experimental conditions. An error of 5 per cent, however, as here mentioned, must be regarded as the maximum, since in most cases a difference of 5 mm. in recording a given pressure represents a far smaller variation in percentage than even a half of this, i.e., 2.5 per cent, since the magnitudes recorded are in nearly all cases more than 200 mm. In some cases, an error of 5 mm. in reading would represent less than one-half of 1 per cent.

Sections of intestine to be tested for bursting were cut so as to measure approximately 5 inches (12.7 cm.) in length in all cases, including those which were made to include an operative enterostomy opening.

Operative Procedure.—The operative procedures were performed under strictly aseptic conditions, under general ether anesthesia by the open drop method and without preliminary narcosis. A high right rectus incision, about 6 cm. long, was employed; after the skin, subcutaneous tissues and rectus sheath had been incised, the belly of the rectus muscle was retracted laterally and the incision completed through the posterior sheath and peritoneum in the line of the incision in the skin; the omentum was pulled upward and displaced to the left, and a loop of jejunum, as near the duodenum as convenient, was delivered through the abdominal wound. Two lateral anastomoses were made in each animal between the limbs of such loops without interrupting the continuity of the lumen around the communicating bend, dependence being placed on the kinking of this area to produce sufficient obstruction to insure the patency of the enterostomy opening (fig. 2), a form of obstruction which proved to be adequate in all cases. Both anastomoses were performed according to exactly the same technic as far as was humanly possible, with the single exception that one was performed with the aid of light intestinal clamps, while the other was performed with the aid of "guy sutures." The clamps used were of the double bladed "Doyen" pattern and were covered with rubber tubing; they were applied solely for purposes of approximation of loops and control of intestinal leakage. The pressure exerted by them was never made so great as to produce any considerable degree of hemostasis or local anemia,

it being assumed that maceration, or even temporary strangulation of tissue, is never a desideratum in operations but rather an occasionaly necessary evil in those cases in which it is allowed to occur; further, such trauma should be of only accidental occurrence in intestinal operations.

In the operation in which clamps were used, the latter were applied to one loop of jejunum, after it was freed of intestinal contents by being milked gently between the gloved fingers, and then a similar clamp was applied to an adjoining loop in the same fashion; both clamps were subsequently brought into such position as to oppose antimesenteric borders for convenient suturing, the clamps then being held in position by two pieces of gauze moistened in

Fig. 2.—Section of the upper jejunum showing the appearance of the entero-enterostomies at the end of four days. The upper suture line is marked by the presence of omental adhesions.

physiologic sodium chloride solution, one tied about the shanks and the other about the tips; the stay sutures consisted of silk ligature and were passed through the serosa and muscularis first of one loop of intestine and then of the opposing loop, the ligature being subsequently tied and left long to permit traction; two of these were used in each case, one at either end of the proposed enterostomy opening. The ends of these "guy sutures" were subsequently cut away, the stitch itself, however, being left in situ, so as to act as an additional reinforcing stitch, as frequently practiced in operations on human beings.

The opening and suturing of the bowel were conducted in routine fashion. The first line of sutures was of silk, size 6; the second line was a whipover stitch of size 0 chromicized catgut, the angles being closed by the classic

"loop on the mucosa" or "Connell" stitch; the third line of sutures was completed with the "right-angled stitch of Cushing," and the fourth line, the continuation of the first line, was also an "anti-leak" right-angled stitch. Needles swedged onto chromicized catgut were used in suturing the second and third suture lines to minimize trauma, but an ordinary intestinal needle was used to carry the silk.

White silk was used to distinguish those entero-enterostomies which were made with "guy sutures," while black silk was used to distinguish those made with clamps. Variations in technic, such as extra sutures at possible weak points, were never permitted, nor was unusual technical care allowed in the case of any animal. The aim throughout the experiments was to approximate the same degree of care taken under actual working conditions in hospital routine. I myself performed all of the procedures with the help of a laboratory technician, previously trained as a nurse, as assistant, and a laboratory diener as anesthetist. The time consumed in performing the operations varied from an hour to an hour and a half or was occasionally longer in cases in which considerable troublesome hemorrhage was encountered.

An attempt was not made to keep a record of the exact operative time, since any attempt to do so might unconsciously have acted as an incentive to a betterment of previous records and so have predisposed to unwise haste. Postoperatively, the animals did not recieve food for twenty-four hours, but were allowed all the water they wanted; feedings of milk were given on the second day, and bread and meat were added to the diet on the third and subsequent days.

Number and Selection of Animals.—In experimental work, one is always somewhat at a loss to know just how many animals should be used for any given experimental series, and the decision must ultimately depend on a number of factors. In this series twenty-nine animals were used, three of which were not included in the final series, for reasons which will be given presently; the plan followed was to operate and perform autopsy on two animals for each successive postoperative day for twelve days, making observations on two dogs directly after operation, and extending the series, by daily autopsies on two dogs, so as to include twelve postoperative days. It was considered that such a series would prove large enough to establish any facts of signal significance, on the one hand, and would, on the other, avoid taxing the experimenter too sorely from the operative point of view.

It was considered advisable in performing these operations to attempt to overcome the factor of possible increasing operative skill, as the series progressed, by the simple expedient of allowing the animals to fall into the series in a haphazard manner; in some of the animals which were operated on early in the series autopsies were performed relatively late, and vice versa; accordingly, the distribution as to operative date will be noted to be virtually a chance distribution.

The course of the investigation extended over a period from Nov. 9, 1927, to March 29, 1928, as shown in table 1.

Since the possible influence of the sex and size of the animals could not be predetermined, and the matter of age, etc., was practically uncontrollable in any case, animals of both sexes and of various sizes, breeds, ages and conditions were selected at random, one enterostomy with clamps and another without clamps being performed on the same animal at a single operation; the enterostomies were performed close together in the same part of the

intestine, in an attempt to make conditions as directly comparable as possible for a given animal. Under such conditions, the two minor variables—(1) the order in which the anastomoses were performed, i.e., whether the technic with clamps or that without clamps was used first, and (2) the order in which the operations occurred in the intestine, i.e., whether oralward or analward—in a given type were considered. It was decided that such variables could best be overcome (*a*) by performing the technic first with clamps in one half of the series and first without clamps in the other half, and (*b*) by allowing the order with respect to the direction of flow of intestinal contents to vary accord-

TABLE 1.—*Data of Investigations*

Dog	Sex	Weight, Kg.	Date of Operation	Date of Autopsy	Postoperative Days
1	F	6.3	11/ 9/27	11/19/27	10
2	F	8.1	11/ 9/27	11/18/27	9
3	F	11.0	11/18/27	11/25/27	7
4*	F	5.2	11/24/27	11/28/27	4
5*	M	12.5	11/24/27	11/28/27	4
6	M	6.2	12/ 6/27	12/12/27	6
7	M	9.5	12/ 6/27	12/13/27	7
8	F	6.0	12/ 9/27	12/15/27	6
9	M	7.1	12/ 9/27	12/17/27	8
10	F	7.0	12/21/27	12/23/27	2
11	M	6.2	12/23/27	12/25/27	Died
12	F	4.5	12/27/27	12/29/27	2
13	F	4.3	12/28/27	12/29/27	1
14	F	11.2	2/15/28	2/26/28	11
15	M	8.2	2/20/28	2/24/28	4
16	F	5.8	2/20/28	2/24/28	4
17	M	5.0	2/29/28	3/ 1/28	1
18	M	10.4	2/22/28	3/ 3/28	10
19	M	9.5	2/22/28	3/ 2/28	9
20	F	10.6	2/29/28	3/ 3/28	3
21	M	9.2	3/16/28	3/24/28	8
22	M	14.4	3/17/28	3/29/28	12
23	M	11.1	3/20/28	3/25/28	5
24	M	6.6	3/20/28	3/31/28	11
25	F	4.8	3/21/28	3/24/28	3
26	M	6.1	3/21/28	4/ 2/28	12
27	F	4.4	3/23/28	3/23/28	0
28	M	6.2	3/23/28	3/28/28	5
29	M	6.5	3/27/28	3/29/28	0

* Dog 11 died on the second postoperative day of general peritonitis. Dogs 4 and 5 were both operated on the same afternoon, and four days later were living and apparently normal; at autopsy, however, they each showed a small area of suppuration at the suture line, which was apparently well walled off by adhesions, but which rendered the animals unfit for the purpose of these experiments. Apparently some unrecognized lapse in aseptic technic occurred on this particular afternoon.

ing to chance. The animals numbered from 1 to 13 are those in which the technic with clamps was performed before that in which "guy sutures" were used, and the animals from 14 to 29 represent the reverse. At operation, an attempt was not made to determine the direction of intestinal flow in a selected loop, and so a record was not made at the time of operation as to the space order (proximal or distal) in which the enterostomies were made; at autopsy it was also frequently impossible to determine what the space order was, until after the loops had been cut apart and burst so as to reveal the identifying silk sutures; by this time there was often a question as to just what the arrangement had been previously, so that attempts to make observations on this particular feature, even at autopsy, were abandoned early.

Standards of Comparison.—The enterostomies were made high in the jejunum in all cases; the exact distance from the pylorus could not be measured at operation, but the variation in the series was not great at autopsy, as shown in table 2.

TABLE 2.—*Distance from Pylorus to First Entero-Enterostomy (Measured at Autopsy)*

Dog	Inches	Dog	Inches	Dog	Inches
1	18	13	12	22	14
2	14	14	14	22	14
3	10	15	12	23	15
6	15	16	13	24	12
7	16	17	15	25	11
8	16	18	18	26	11
9	9	19	13	27	12
10	12	20	15	28	18
12	12	21	16	29	12

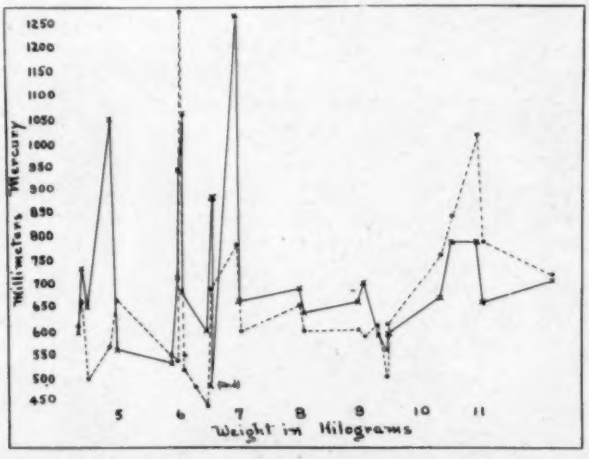

Fig. 3.—Graphic representation of the bursting pressure of segments of intestine removed just cephalad (broken line) and caudad (solid line) to the entero-enterostomies, in relation to the weights of the dogs used. The bursting pressures of the caudad segments average 7.4 per cent higher than those cephalad, but the bursting pressures do not bear any evident relation to the weights of the animals.

The pressure required to burst normal intestine in this region (i.e., the upper jejunum) was found by excising two segments of intestine, one just proximal to the two entero-enterostotomies and the other just distal; these were burst and averages were made of the two bursting pressures. That this represents the true normal bursting pressure in animals not operated on is, of course, questionable, since the adjacent operative procedure may well have affected these segments also. To estimate the percentage of strength of the two intervening entero-enterostomies, the bursting pressure for each was measured and the percentage of strength computed as a decimal fraction by dividing this pressure by the average normal pressure previously determined.

RESULTS

The results have been tabulated and reproduced. Figure 3 represents the various bursting pressures of the caudal and cephalad segments of the normal jejunum removed, as previously described, from just above and just below the entero-enterostomies. It is interesting to note that the bursting pressure of the distal or caudal segment averages nearly 7.5 per cent stronger than that of the proximal segment, the distance of intestine intervening between the two being approximately 10 inches (25.4 cm.). Expressed in millimeters of mercury, the average difference is 39.2 mm., which is certainly a significant difference. Whether the presence of the intervening entero-enterostomies is to be considered as the cause of this difference in bursting pressure or whether the difference is inherent in the intestine of the normal animal cannot, as previously suggested, be determined from these experiments.

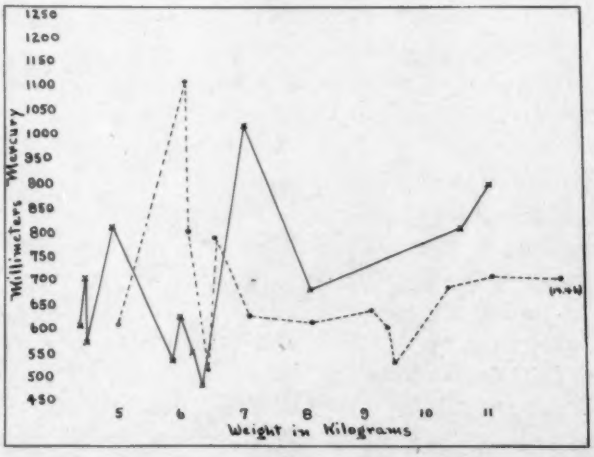

Fig. 4.—Graphic representation in which the bursting pressures of both cephalad and caudad segments are averaged and plotted with respect to the sex of the animals used. There is a slight but distinct trend toward greater strength in the female intestine. The solid line indicates females and the broken line, males.

It is also interesting to note in connection with this graph that the strength of the segments of normal intestine does not bear a simple relation to the weight of the animal. Possibly, on the whole, there is a slight tendency for the bursting pressure of the intestine of larger dogs to be greater, and that of smaller dogs to be less, but the exceptions are so numerous and of such magnitude that one is hardly justified in drawing such a conclusion from this series of animals. On the contrary, it is probably not without significance that occasionally, at least, small dogs have high intestinal bursting pressures, while larger dogs

frequently show the reverse. The occasional considerable variation in bursting pressure between the proximal and distal segment is also interesting.

Figure 4 represents graphically the relation between the strength of the normal intestine and the sex of the animals. Thirteen males and thirteen females are represented, although this equal sex distribution occurred by chance. On the whole, the bursting pressure of the female intestine is greater than that of the male, weight for weight, though here again there are many exceptions.

Position and Character of Rupture of Normal Intestinal Segments.—Table 3 shows in detail the position and character of the ruptures which occurred in segments of normal intestine.

Three general varieties were noted: (1) the rupture at the antimesenteric border, by far the most common variety; (2) rupture at the mesenteric border, of much less frequent occurrence, and (3) intermediate rupture, a still less frequent variety, which occurred between the mesenteric and antimesenteric borders.

Bursting of the most common, or antimesenteric, type occurred in 74.1 per cent of the cases, of which a few presented a more or less slow leak (5 per cent), while by far the greatest number (69 per cent) presented diffuse bursting with explosive violence. In the latter the bursting usually involved a more extensive rupture of the submucosa and mucosa than of the peritoneal coat, so that the peritoneal coat characteristically extended, stretched but unbroken, over considerable areas of the underlying ruptured tunics; occasionally, however, the rupture of all tunics was coextensive. The length of rupture of all coats varied from half an inch to the entire length of the segment in some cases. The explosion usually rivaled the detonation of a giant firecracker.

Mesenteric rupture was noted in 17.2 per cent of the cases and presented the same two subtypes as noted previously, i. e., (*a*) slow leak (6.8 per cent) and (*b*) diffuse explosive rupture (10.3 per cent); the explosive force and extent of the mesenteric rupture was always, however, less than that of the antimesenteric variety. The type called "intermediate" occurred in 8.9 per cent of the cases, of which half (two cases) presented slow leaks, and the other half, diffuse rupture.

Place of Rupture of the Entero-Enterostomy Opening.—Table 4 shows the places at which rupture of the various entero-enterostomies occurred; since the table represents so many different postoperative time intervals, it is difficult to interpret and probably should not be interpreted closely.

The place of rupture in most cases is apparently the point of maximum mechanical strain. In only four cases in the series was rupture

TABLE 3.—*Position and Character of Rupture of Segments of Normal Jejunum*

Oral Segment

Dog	Diffuse Antimesenteric (Explosive)	Antimesenteric (Slow Leak)	Diffuse Mesenteric (Explosive)	Mesenteric (Slow Leak)	Intermediate (between Antimesenteric and Mesenteric Borders)
1	..	..	..	..	+ (slow leak)
2	+	..	..	..	..
3	+	..	..	..	..
6	..	..	+	..	..
7	+	..	..	..	..
8	..	..	..	+	..
9	..	..	..	..	+ (diffuse explosive)
10	+	..	..	..	..
12	+	..	..	..	..
13	+	..	..	..	..
14	+	..	..	..	..
15	+	..	..	..	..
16	..	..	+	..	..
17	+	..	..	..	..
18	+	..	..	..	..
19	+	..	..	..	..
20	..	..	+	..	..
21	..	+	..	..	..
22	+	..	..	..	..
23	..	..	+	..	..
24	..	..	..	+	..
25	+	..	..	..	..
26	+	..	..	..	..
27	..	..	..	..	+ (slow leak)
28	+	..	..	..	..
29	+	..	..	..	..
Total	18	1	4	2	3

Aboral Segment

1	+	..	..	..	..
2	..	..	..	+	..
3	+	..	..	..	..
6	..	..	+	..	..
7	+	..	..	..	..
8	+	..	..	..	..
9	+	..	..	..	..
10	..	+	..	..	..
12	+	..	..	..	..
13	..	..	..	..	+ (explosive)
14	+	..	..	..	..
15	+	..	..	..	..
16	+	..	..	..	..
17	+	..	..	..	..
18	+	..	..	..	..
19	+	..	..	..	..
20	+	..	..	..	..
21	+	..	..	..	..
22	..	+	..	..	..
23	+	..	..	..	..
24	+	..	..	..	..
25	+	..	..	..	..
26	+	..	..	..	..
27	+	..	..	..	..
28	..	..	+	..	..
29	+	..	..	..	..
Total	22	2	2	1	1

through the normal intestinal wall noted, and these cases all fell within the postoperative interval of eight to ten days. That rupture at the angle of the suture line did not occur more frequently probably cannot be interpreted as meaning that this point was unusually strong, but rather that the particular way in which the enterostomies were made tended to throw stress along the side of the entero-enterostomy rather than at the angle.

The crux of the investigation is represented in figures 5 and 6 and concerns the relative strength of the enterostomies themselves as conva-

TABLE 4.—*Position of Rupture of Entero-Enterostomies*

	With Clamps			Without Clamps		
Dog	Near Angle of Suture Line	Along Side of Suture Line	Outside Suture Line	Near Angle of Suture Line	Along Side of Suture Line	Outside Suture Line
1	..	..	+	+	..	..
2	..	..	+	+	..	..
3	..	+	..	..	+	..
6	+	..	..	..	+	..
7	..	+	..	+	..	..
8	+	..	..	+	..	..
9	..	+	..	..	..	+ (8 days)
10	+	..	..	..	+	..
12	+	..	..	..	+	..
13	..	+	..	+	..	..
14	+	..	..	+	..	..
15	..	+	..	..	+	..
16	..	+	..	..	+	..
17	..	+	..	..	+	.. (10 days)
18	..	..	+	+	..	..
19	..	+	..	..	+	..
20	+	..	..	..	+	..
21	..	+	..	..	+	..
22	+	..	..	..	+	..
23	..	+	..	+	..	..
24	..	+	..	..	+	..
25	+	..	..	+	..	..
26	..	+	..	..	+	..
27	+	..	..	+	..	..
28	+	..	..	..	+	..
29	..	+	..	..	+	..

lescence of the animals proceeded. Two bursting pressures are plotted for each postoperative day; the solid black blocking at the bottom of the graphs represents the lesser bursting pressure and the lighter blocking above, the greater bursting pressure of each of two animals. Immediately following the operation, performed by either method, the enterostomies show a strength roughly between 20 and 40 per cent of that of the normal intestine; with both methods, for the first three days, the strength progressively decreases to a minimum on the third day of roughly between 15 and 25 per cent, and on subsequent days the strength progressively rises to a maximum, about the tenth day, of between 90 and 110 per cent of normal, the normal intestine rather than the enterostomy occasionally rupturing toward the end of this period. On

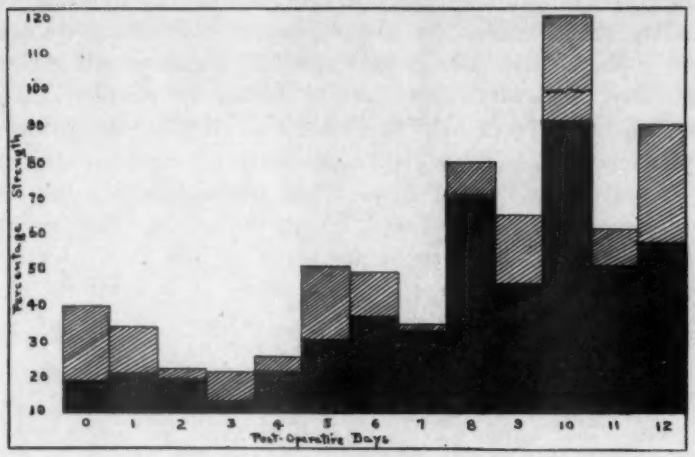

Fig. 5.—Graphic representation in which the bursting pressure of entero-enterostomies made without clamps (with "guy sutures") is plotted for twelve postoperative days, two observations being plotted for each day. The bursting pressure declines for the first three days, rises for the next seven days and declines again during the last two days.

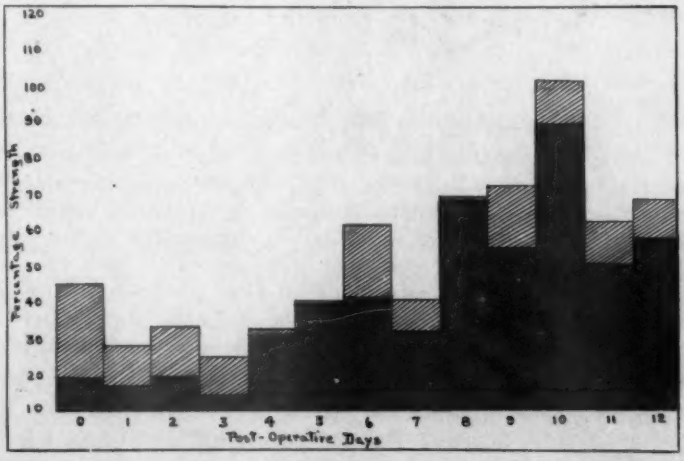

Fig. 6.—Graphic representation in which the bursting pressure of entero-enterostomies made with clamps is plotted for twelve postoperative days, two observations being plotted for each day. The bursting pressure declines for the first three days, rises for the next seven days and declines again during the last two days.

the eleventh day, however, the strength of the enterostomies has again decreased to approximately half of normal, but on the following, or twelfth day, seems again to be on the increase. When one compares the strength of those enterostomies performed with clamps with the strength of those performed with "guy sutures," as shown in figure 7, it is seen that not much difference is to be found, though if anything, the technic employing clamps seems to yield a stronger entero-enterostomy, especially at the critical period, i. e., when the operative anastomosis is weakest, between the second and fourth days. In this connection, it should be noted that the graphs are made on the basis of percentage strength, rather than on that of millimeters of mercury; 1 per cent on the graph represents, on the average, 5.85 mm. of mercury.

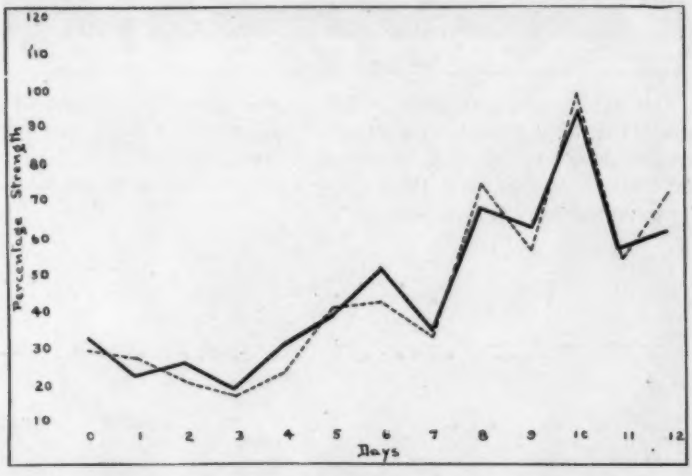

Fig. 7.—Graphic representation in which the bursting pressure of gastro-enterostomies performed with clamps is plotted against the bursting pressure of those performed without clamps (i.e., with "guy sutures") over a period of twelve postoperative days. Each day is represented by averaging the results from two dogs, four enterostomies being plotted for each day—two with clamps and two without. The entero-enterostomies performed with clamps are slightly stronger than those performed without clamps, the greater strength being apparent on the second, third and fourth days during which the entero-enterostomies performed by both methods are weakest.

These results check fairly well with the experiments of Chlumsky,[1] who found the bursting pressure of entero-enterostomies in dogs to be (1) one third of that of the normal intestine immediately after operation; (2) to decrease progressively for four days to one third of the latter pressure; (3) to rise progressively to their original strength

1. Chlumsky, quoted by Bartlett: After Treatment of Surgical Patients, St. Louis, C. V. Mosby Company, 1920, vol. 2, p. 810.

on the seventh day, and (4) to equal the intact intestinal wall on the tenth day. According to the present experiments, however, as already noted, the bursting pressure is lowest on the third and not the fourth day, it supersedes the original bursting pressure on the fifth and subsequent days, rather than merely reaching such pressure on the seventh day and shows a marked decrease on the eleventh day, which Chlumsky did not note.

CONCLUSIONS

1. A constant relationship does not exist between the weight of a dog and the bursting pressure of its upper jejunum, the intestine of larger dogs often showing relative weakness and that of smaller dogs relatively extreme strength.

2. Under the conditions of these experiments, segments of the upper jejunum 12 inches (30.4 cm.) or more cephalad to other segments show an average difference of bursting pressure of more than 7 per cent in favor of the distal segment.

3. The jejunum of female dogs is slightly stronger than that of males, weight for weight.

4. Entero-enterostomies performed by both "clamp" and "clampless" technics are about one-third as strong as normal intestine immediately after they are performed; they progressively decrease in strength for three days, then rapidly and progressively increase in strength up to, or exceeding, the strength of normal intestine by the tenth day, then suddenly fall again to about 50 per cent of the intact intestine on the eleventh day, and on the twelfth are again on the ascent.

5. Entero-enterostomies performed with clamps, when the latter are used merely for purposes of "approximation of the parts and for control of intestinal leakage" are, if anything, slightly stronger than ones performed with "guy sutures," especially on the second, third and fourth postoperative days, which constitute the critical period.

6. Entero-enterostomies performed by either method and on all postoperative days, up to and including the twelfth, showed marked variations in strength, even though operative technic was kept as constant as humanly possible and postoperative care was the same in all cases, variations exceeding 100 per cent being noted frequently in the early three or four days and variations of the order of magnitude of 50 and 75 per cent being common throughout the entire twelve days.

7. The normal upper jejunum ruptures most characteristically (i. e., in about three fourths of the cases) at its antimesenteric border, though less frequently it ruptures at its mesenteric border, and occasionally at a point intermediate between the two; the characteristic rupture is a diffuse one with explosive violence and involves the mucosa and submucosa more extensively than the serosa.

TRAUMA AS A FACTOR IN ACUTE APPENDICITIS

ADDISON H. BISSELL, M.D.
STAMFORD, CONN.

Because of the many instances in which compensation has been denied, trauma as a factor in producing appendicitis deserves attention. The pathologic evidence agrees with well known experimental observations. When there is a history of trauma to the abdominal wall, followed by symptoms and signs of peritoneal irritation, the examiner should bear in mind the possibility of an inflammation of the appendix. Von Neumann [1] reported that trauma plays a part in the cause of acute appendicitis in 6.6 per cent of the cases. The four cases reported here occurred in 101 appendectomies, making trauma an etiologic factor in 4 per cent.

The Idaho Commission [2] said that appendicitis from strain is not a probability, and rarely, if ever, occurs.

In a case [3] which occurred in California, the employee suffered a strain while lifting heavy objects, and felt a severe abdominal pain. Autopsy six days later revealed a ruptured gangrenous appendix. Expert testimony was to the effect that this was merely a coincidence. In numerous other incidences, employers have contended that appendicitis is not caused by trauma.

Many cases of traumatic appendicitis have been reported by Smith,[4] Soresi,[5] Sherrick [6] and others. Deaver [7] said he had "never seen a case of acute appendicitis in which injury was alleged as the direct exciting cause in an appendix that did not show some evidence of previous disease. It is well known that foreign bodies, fecal concretions, strictures of the appendix, and adhesions, are frequently present without giving the patient any trouble or suggestion of a lesion in the right iliac fossa."

The experiments of Furbinger and von Hansemann [8] showed that they were able to express the contents of a full cecum into the appendix by light manual pressure over the cecum and ascending colon, and by

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1. VonNeumann, quoted by Choyce: System of Surgery, New York, Funk & Wagnalls Company, 1912, p. 541.
2. Research Report no. 61 National Industrial Conference Board, August, 1923, p. 133.
3. Murphy v. Southwest Shipbuilding Co. Cas. Industrial Com. Decisions, vol. 7, p. 114.
4. Smith: Brit. M. J. **1**:283, 1923.
5. Soresi: M. Rec. **99**:718, 1923.
6. Sherrick: Illinois M. J. **2**:153, 1915.
7. Deaver: New York M. J. **85**:1105, 1907.
8. Furbinger and von Hansemann, in Ludington, N. A.: Etiology of Traumatic Appendicitis, J. A. M. A. **80**:1448 (May) 1923.

the introduction of air into the rectum. It is logical that a blow on the abdomen, or a muscular strain, would probably force cecal contents into the appendix. If the appendix was normal and its lumen unobstructed, it might conceivably rupture, for, as Warbasse [9] said, if blows can rupture a normal intestine why can they not rupture the appendix? Especially does this seem possible when one considers the small lumen of the appendix, its blunt end and its rudimentary character, and remembers that an increase in the diameter is tripled in its circumferential measurement. If the appendix was normal and did not rupture, it would empty itself and harm would not result.

If, however, due to fecal concretions, adhesions, stricture of its lumen or other disease, the appendix would be unable to empty itself, fecal stasis [8] would result. This condition is recognized as favorable to infection. Ludington [8] favored fecal stasis as the main cause of appendicitis following trauma to the abdominal wall.

Van Buren,[10] experimenting on dogs, found that increased intraintestinal pressure caused pressure hemorrhage at the antimesenteric surface of the intestine. He observed the condition clinically only in cases of mechanical ileus, and reported perforation on the antimesenteric surface of the intestine, usually quite close to the point of obstruction. The necrotic area corresponds roughly to the terminal anastomotic tree of the intestinal vessels, and is evidently the result of hemorrhagic infarct of the area supplied. This necrosis is usually evident first in the submucosa and inner muscular coat, but it rapidly extends to the other coats of the intestinal wall, and perforation may occur within twenty-four hours after the discoloration due to the hemorrhagic infarct is first noticed.

Following the application of force to the external abdominal wall, it is easy to visualize a rush of cecal contents into the lumen of the appendix. This force might theoretically rupture the appendix, but this undoubtedly seldom happens. It is also easy to visualize this force as causing mucosal or mucosomuscular tears, with fecal stasis, and rapid invasion of the appendix wall by pathogenic organisms. Concretions, strictures of the lumen and adhesions would increase the chances of this occurring. From the pathologic condition of the appendixes reported here it seems probable that the rush of cecal contents jammed a concretion far down in the appendix, and that from this obstruction necrosis and perforation took place on the antimesenteric side. The concretion may be considered the obstructive lesion, and the pathologic changes may be explained according to Van Buren's observation on mechanical ileus.

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9. Warbasse, quoted by Behan: Ann. Surg. **85**:263 (Feb.) 1927.
10. Van Buren, F. J.: Tr. South. Surg. Soc. **36**:445, 1923.

To argue as to whether the organ was normal or not is beside the point, for the abnormalities that make for easy invasion of the appendix by infection after injury are compatible with good health, and often impossible to diagnose. The question should be whether an abdominal injury, or unusual strain, can precipitate the clinical picture of acute appendicitis? There does not seem to be any doubt that this can take place. The trauma is the deciding factor.

REPORT OF CASES

CASE 1.—O. G., aged 14, who had not had any previous attacks of appendicitis, while playing football two days before admission fell forward striking his abdomen on a rock. He felt severe abdominal pain immediately and vomited. The abdominal pain was severe at first, was somewhat lessened after an hour, but was constantly present to the time of operation. On the second day, his physician brought him to the hospital, where I performed an emergency operation on May 21, 1924. The wall of the cecum was injected and thickened. The right iliac fossa was the site of a large abscess, and free in this abscess was a concretion. The appendix was long, coursing down and in over the pelvic brim, and its distal half was necrotic. The whole appendix was acutely inflamed. Near the tip there was a perforation 1 inch (2.5 cm.) long opposite the attachment of the mesentery. Appendectomy with drainage was performed. The patient recovered.

CASE 2.—R. S., aged 10, without any previous history of appendicitis, received a severe kick in the abdomen while playing football. He felt immediate abdominal pain, was nauseated and vomited. He "felt faint" in the upright position, and was chilly. He was kept in bed at home for six days without being seen by a physician and suffered constantly from severe abdominal pain, nausea, vomiting, chills, distention and constipation. On the sixth day, he was sent by a physician to the hospital, where I performed an operation immediately on Sept. 24, 1925. A marked generalized fibrinopurulent peritonitis was present. The appendix was 3 inches (7.6 cm.) long and necrotic throughout. Near the tip there was a perforation 1 inch (2.5 cm.) long, with markedly thickened, everted edges. A large concretion was found in the pus near the perforation, which was on the external lateral aspect of the appendix. Appendectomy with drainage was performed, and the patient recovered. There was fecal drainage in decreasing amounts for five days.

CASE 3.—T. F., aged 19, who had not had any previous attacks of appendicitis, forty hours before operation was performed, had been thrown on his back while wrestling, and his oppenent had jumped on his abdomen. The patient said that he "felt something crack" in his abdomen, and felt immediate colicky abdominal pain. For an hour or so, he was nauseated. The colicky pain, which was not severe, kept up constantly until twelve hours after injury when all his symptoms became much worse, and were localized in the right lower quadrant. He vomited frequently, complained of being chilly and, after twenty-four hours, became delirious at times. Forty hours after the injury occurred, he was brought to the hospital, where I performed an emergency appendectomy on April 27, 1926. The appendix was 4 inches (10.16 cm.) long, in normal position, and was not adherent. The entire appendix was markedly inflamed, and the distal half was necrotic. There was a perforation 1 inch (2.5 cm.) long near the tip on the antimesentery side. A general peritonitis was present without the slightest evidence of any

walling off process. He did not show any improvement after his operation, and died on the third day. Two concretions were found in the region of the appendix, free in the purulent material that filled the abdominal cavity.

CASE 4.—D. S., aged 18, who had not had any previous attacks of appendicitis, fell hard while skating, striking his buttocks. He felt pain immediately around the umbilicus and in the right lower quadrant. He felt faint and chilly, was nauseated and vomited once. Shortly after the accident, his abdominal pain lessened somewhat, but it was present constantly to the time of operation. After twelve hours, his abdominal symptoms became more marked, and they steadily increased in severity until I saw him twenty-six hours after his fall; I performed an appendectomy immediately. A general peritonitis was present, a large abscess cavity was observed in the right lower quadrant, and a concretion was found in this cavity. The appendix was 2½ inches (6.27 cm.) long; its wall was thickened and necrotic. Near the tip was a perforation 1 inch (2.5 cm.) long, with everted edges. This perforation was on the side opposite the mesentery. The patient recovered after the appendectomy with drainage.

CONCLUSIONS

1. At the time of injury all these patients were in good health.

2. A history of previous attacks of acute appendicitis could not be obtained in any case.

3. There was, in each case, a definite history of severe trauma, with immediate abdominal pain, nausea and vomiting. The symptoms were continuous up to the time of operation.

4. In each case, a perforation opposite the mesentery was found in the appendix. In each case, a concretion was recovered which presumably had perforated through the appendix. I believe that the trauma caused the concretion to impinge tightly in the lumen of the appendix resulting in an obstruction in that organ, with hemorrhagic infarction, necrosis and perforation on the antimesenteric border, bearing out the observation made by Van Buren on mechanical ileus.

EMPYEMA IN INFANTS UNDER TWO YEARS OF AGE*

WILLIAM FRANCIS RIENHOFF, JR., M.D.
BALTIMORE
AND
WILBURT C. DAVISON, M.D.
DURHAM, N. C.

Prior to the World War, the fatality rate (mortality) of empyema in infants under 2 years of age who were treated surgically was far too high. In infants under 2 years of age, fatality rates up to 66 per cent have been reported.[1] The younger the patient, the higher is the rate; Holt and Howland reported that it was 71 per cent in children under 1 year of age and 59 per cent in those in their second year.[2] Farr and Levine found the fatality to be four times greater during the first year than in the fourth and that it steadily declined up to 6 years of age, after which the deaths occurred relatively seldom.[3] Wilensky reported a fatality of 48 per cent for the first year and 31 per cent during the second.[4] Practically the same figures have been published by Poynton and Reynolds,[5] Ladd and Cutler[6] and Bohrer,[7] all of whom reported in infants under 2 years of age a fatality rate of 35.4 per cent followed by a marked decrease in the frequency of deaths after the age of 2 years. However, the pediatric and surgical staffs were not proud of their results and took counsel among themselves for measures to improve them. The striking benefits which followed late operation, preceded by therapeutic aspirations and simpler methods of treatment of persons

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* From the Departments of Surgery and Pediatrics of the Johns Hopkins University School of Medicine and Hospital and the Harriet Lane Home.

* Read at the Fifty-Eighth Annual Meeting of the Medical Society of Virginia, Petersburg, Va., Oct. 19, 1927.

1. Thursfield, H.: The Treatment of Empyema in Infants and Young Children, St. Bartholomew's Hosp. J., Nov., 1922, pp. 1-10. Holt, L. E., and Howland, J.: The Diseases of Infancy and Childhood, ed. 9, New York, D. Appleton & Company, 1926, pp. 442-449. Poynton, F. J., ad Reynolds, F. N.: A Method for Diminishing Mortality in Empyema in Infancy and Childhood, Lancet **2**: 1100, 1921.

2. Holt and Howland (footnote 1, second reference).

3. Farr, C. E., and Levine, M. I.: Empyema in Children, Surg. Gynec. Obst. **46**: 79 (Jan.) 1928.

4. Wilensky: Empyema of Thorax, Surg. Gynec. Obst. **20**: 501, 1915.

5. Poynton and Reynolds (footnote 1, third reference).

6. Ladd, W. E., and Cutler, G. D.: Empyema in Children, Am. J. Dis. Child. **21**: 546 (June) 1921.

7. Bohrer, J. V.: Treatment of Acute Suppurative Pleurisy in Children, Am. J. Surg. **3**: 232, 1927.

with empyema during the war, especially at Camp Lee, Va.,[8] led to the increased utilization of the closed thoracotomy or the operation[9] in which the trocar and cannula were used, in this hospital, and to the gradual reduction in the number of open thoracotomy or rib resections, the surgical method which has been employed almost exclusively up to 1919. Both of these operative procedures have now been used for the last nine years, and an analysis of the results has been made in order to determine whether the fatality rate had been decreased, and if not, to learn what might lead toward a reduction.

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8. Dunham, E. K., and others: Report of Empyema Commission, U. S. A.: Cases of Empyemata in Camp Lee, Va., J. A. M. A. **71:** 366 (Aug. 3) 1918; **71:** 443 (Aug. 10) 1918.

9. The two types of operation used in this series of cases have been the closed trocar and cannula method and the open thoracotomy or rib resection. The latter is familiar to every surgeon and need not be described here. The method in which the trocar and cannula are used is performed as follows: The skin and subcutaneous tissue over the area of most marked flatness, usually the seventh and eighth interspace between the middle and posterior axillary lines, is infiltrated with 0.5 per cent novocaine. A small incision (about 0.5 cm.) is then made in the skin and the rather blunt trocar and cannula (*B* in illustration) inserted, as shown in the accompanying illustration. After the trocar has passed the skin and subcutaneous tissue, the point is shifted as far laterally as possible and then forced through the intercostal muscles into the pleural cavity. This diagonal insertion of the trocar insures a more tightly fitting connection about the tube and thus prevents the subsequent leakage of air into the pleural cavity and also the escape of the exudate onto the wall of the chest and the formation of cellulitis. The trocar should be guarded against too deep penetration by placing the fingers on the trocar at a distance from the point approximately equal to the thickness of the wall of the chest. A rubber catheter (no. 20 or larger) clamped at the end is inserted into the side arm of the cannula (*B*) and then, as the trocar is removed, into the main tube of the cannula. The cannula is then slipped out over the catheter, leaving the latter inserted in the pleural cavity. One arm of a Y-shaped glass tube is then connected to the catheter, another arm to a 1 liter gravity flask containing warm sterile salt solution suspended 6 feet from the floor, and the third arm to a 2 liter drainage bottle placed on the floor beside the bed. The rubber tubing of the two latter connections is compressed by clamps, as shown in the illustration, but while these connections are being made salt solution is allowed to run into the Y-shaped glass tube from the gravity flask in order to expel any air in the system. The clamps on the catheter and on the connection to the gravity flask are then removed and from 25 to 50 cc. of salt solution is permitted to flow into the empyema cavity. The upper clamp is then replaced, the clamp on the connection to the collection bottle removed and the empyema cavity is thus drained. The end of the rubber tubing going to the collection bottle should always be under water to prevent the ingress of air into the system. This flushing and draining of the pleural cavity can be repeated at various intervals. During the remainder of the time the upper clamp should be in place and the lower clamp removed so that the cavity may drain continuously. Surgical solution of chlorinated soda (Dakin's solution) can advantageously be substituted for the salt solution at the end of forty-eight hours.

We searched [10] all of the records of case histories of the Johns Hopkins Hospital since its opening in 1889 and of the Harriet Lane Home (the Children's Department of the Johns Hopkins Hospital) from its beginning in 1914, and were able to find reports of only eighty cases of empyema in infants under 2 years of age. The first patient was admitted to the hospital, Dec. 8, 1914, and the first operation was done, May 25, 1915. It is, of course, possible that there may have been other infants in whom empyema was diagnosed and not recorded, but it is more likely that the diagnosis of empyema in young infants in this hospital was relatively uncommon prior to 1914 and that operations for this condition in small infants were rarely performed before 1915.

Of these eighty patients, thirty-two were not operated on. In twenty of these, the diagnosis was not made until autopsy. The

All of the Infants Two Years of Age and Under with Empyema Admitted to the Johns Hopkins Hospital from 1889 to June, 1927, Whose Records Could be Found

Forty-eight patients who were operated on for empyema (rib resection—open thoracotomy—or the insertion of a trocar and cannula—closed thoracotomy), 19 of whom, or 39.6 per cent died.

Nine patients who had one or more thoracenteses performed (needle and syringe) and no further operation; 1 of these 9 patients recovered; 6 of them died within forty-eight hours of the diagnosis of empyema before an operation could be performed.

Three patients who were taken elsewhere for treatment after the diagnosis had been established by thoracentesis; their subsequent history is unknown.

Twenty patients in whom the diagnosis of empyema was not made until autopsy.

Total, 80 patients.

clinical diagnosis in each instance was pneumonia. Whether recovery would have been possible if the presence of empyema had been ascertained and proper treatment instituted is impossible to state. It is also unreasonable to allege that every case of empyema in infants in which the diagnosis is not made is fatal, for naturally we do not know in how many undiagnosed cases the patients recovered. However, the fact that among a total of eighty proved cases of empyema in infants under 2 years of age in this hospital, in 20 or 25 per cent of the total the diagnosis was not made until autopsy should be a warning to pediatricians to be on their guard.

There are several reasons for this failure to diagnose empyema in infants: First, the area of the chest is small, and it is often difficult to distinguish by percussion a small area of flatness from the surrounding pulmonic dulness. Secondly, most physicians hesitate to make repeated

10. We wish to express our thanks to Miss R. Frances Riach and to Miss Laura Hodges for their assistance in locating these histories.

diagnostic thoracenteses. The insertion of a needle into the thoracic cavity is not entirely devoid of danger to the patient, and occasionally a serious and sometimes fatal pyopneumothorax may follow a needle puncture of the lung; in rare instances, sudden death from the so-called pleural reflex may occur. However, the case fatality rate of infants with empyema in whom the condition is undiagnosed and untreated is so much higher than it is among patients in whom needless punctures have been made for suspected empyema that Osler's admonition to a young intern should be profitably followed: "In any case of presumptive empyema, an exploring needle should be inserted in seventy times seven places before the possibility of empyema can be eliminated." The third difficulty in the diagnosis of empyema is that roentgenograms of the involved lung frequently are not of much assistance in helping one to distinguish between pneumonia and empyema, particularly if there is only a thin layer of fluid. Flouroscopy should be more commonly used in the diagnosis of pulmonary disease in children, particularly if the presence of fluid is suspected. If one changes the infant's position on the fluoroscopic table, the level of the fluid or pus can be much more easily detected than is possible in a routine roentgenogram. Furthermore, the use of an exploring needle in the fluoroscopic room usually decreases one's failures in the diagnosis of empyema.

The remaining twelve of the thirty-two cases of empyema in infants under 2 years of age in which an operation was not performed were made up of three in which the result is unknown, for the infants were taken elsewhere for treatment after the diagnosis had been made by thoracentesis in our outpatient department, and of nine in which the treatment consisted of single or repeated aspiration of the pus in the chest with a syringe and needle. Eight of these nine infants died. These nine instances of aspiration with eight deaths, of course do not indicate that this procedure is worthless as a therapeutic measure, for six of the patients died before an operation could be performed. Thoracentesis in these cases should be classified as a diagnostic or a preoperative procedure rather than a therapeutic measure. Others who have relied solely on this form of treatment have reported good results. However, Holt and Howland reported that of 139 patients treated by aspiration alone 13 died; 101 were later operated on, and 25 were cured, 8 of them by a single aspiration.[3]

Our main interest lay in the forty-eight cases in which either the open thoracotomy (rib resection) or the closed thoracotomy (in which the trocar and cannula were used) had been performed. We obtained the following data from every history in which they were recorded: name, hospital number, address, age, sex, color, weight, date of admission, result, date of last observation, length of postoperative observation, duration before admission, length of the interval between the onset of

pneumonia and the operation, length of the postoperative stay in the hospital, nutrition, digestive condition and general physical condition of the patient, symptoms, temperature, white blood count and hemoglobin content on admission, examination of the urine, preceding infection, physical signs, location of the empyema, etiology, tuberculin reaction, preoperative and postoperative x-ray, operator, date, type and length of operation, type of pus in the empyema cavity, type of anesthetic used, pulse, respiration and temperature during and after the operation, local and general postoperative treatment, postoperative feeding, postoperative weight curve, time required for sterilization and expansion of the lungs, preoperative and postoperative complications and the cause of death in fatal cases.

DATA OF CASE HISTORIES

We arranged this mass of data in tables,[11] first finding the median (average), minimum and maximum value for each factor and then determining the effect which this factor had on the case distribution [12] and the fatality rate [13] (mortality). We found (table 1) that the cases were fairly and uniformly distributed in the various component groups and that most of the factors had more or less influence on the fatality rate, as, for example, the fatality rate in infants in the first year of life was slightly higher than that in those in their second year. The most striking effect was exerted by the following factors: the physical condition of the patient, location of the empyema, etiology, complications and the type of operation.

Physical Condition of the Patient.—One half of the patients were in poor physical condition. As would be expected, the case fatality rate was highest among infants in poor physical condition.

Location of the Empyema.—The cases were quite evenly distributed between those of empyema on the left side and those of empyema on the right. The fatality rate was highest in infants who had left sided and double empyema. That double empyema should be more fatal is to be expected but why should empyema on the left side have a fatality rate nearly twice as high as that of involvement of the right side? Can the displacement and compression of the heart with the associated cir-

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11. We are indebted to Dr. Raymond Pearl for instructing us in the statistical methods necessary for the analysis of these data. For the sake of brevity, only six of the tables are included in this paper.

12. Case distribution refers to the percentage of the total number of surgically treated patients suffering from empyema that occurs in each group, i. e., in table 2, twenty-six of the total number (forty-one) of patients had pneumococcus empyema or a case distribution of 26:41, or 63.5 per cent.

13. The case fatality rate is calculated with reference to the number of patients in each group, i. e., in table 2, of the twenty-six patients who had pneumococcus empyema, eight died, or a case fatality rate of 8:26, or 30.8 per cent.

culatory embarrassment which is usually greater in empyema on the left than that on the right be the explanation.

Etiology (table 2.)—Similar to the series described by Holt and Howland,[2] nearly two thirds of the infections were due to pneumococci. Fortunately, the fatality rate in pneumococcal infections was only one half of that in infections due to other organisms. Although there were only four patients who had streptococcus empyema, so that definite conclusions cannot be made, this organism is apparently the most dangerous of all.

TABLE 1.—*Summary: The Distribution of Cases and Deaths in Relation to Various Factors*

Factor	Case Distribution	Case Fatality
Age	Slightly higher in infants in second year of life	Slightly higher in infants in first year of life
Sex and color	Highest in white males	Lowest in white males
Weight	Highest in infants under normal weight	Highest in those least under normal weight
Interval between onset of pneumonia and operation	No apparent relation	No apparent relation
Length of stay in hospital of patients who survived	35 days was the median (average) stay in the hospital	
Length of survival in fatal cases	.....	One half of the deaths occurred within the first four days after operation
Patient's condition	Highest in infants in poor condition	Highest in infants in poor condition
White blood count	No apparent relation	Lowest in infants with white blood counts between 20,000 and 30,000
Hemoglobin	Highest in infants with a low hemoglobin content	No apparent relation
Location of empyema	No apparent relation	Higher in infants who had left sided and double empyema
Etiology	Highest in infants who had pneumococcus infections	Lowest in infants who had pneumococcus infections
Type of operation	No apparent relation	Higher in infants on whom the trocar and cannula operation or closed thoracotomy was performed
Type of pus	Higher in infants who had thick pus	No apparent relation
Type of anesthetic	No apparent relation	No apparent relation
Complications	Higher in infants without complications	Higher in infants who had complications

Complications (table 3.)—The fatality rate was four times higher among the infants who developed complications than in the group who did not. Although the development of complications may have been merely an index of the lack of resistance in these infants who were ill, it is probable, as will be brought out later, that they are the most important factor in the fatality rate, and that every precaution should be taken to avoid them.

Type of Operation (table 4).—It was surprising to us, for we had expected quite the opposite, to find that the fatality rate among infants in whom a closed thoracotomy (in which the trocar and cannula were used) had been performed was nearly twice as high as that in the group

in which rib resection was done. Instead of decreasing the fatality rate in empyema in infants under 2 years of age the use of the trocar and cannula with siphon drainage had actually increased the number of deaths. This observation illustrates the advisability of analyzing hospital

TABLE 2.—*The Distribution of Cases and Deaths in Relation to the Etiology*

Etiology	Number of Patients	Case Distribution, per Cent	Number of Deaths	Case Fatality, per Cent
Pneumococcus	26*	63.5	8	30.8
Staphylococcus aureus	8†	19.5	3	37.5
B. influenzae	3‡	7.3	2	66.6
Streptococcus	4§	9.7	4	100
(Nonpneumococcus)	(15)	(36.5)	(9)	(60)
Total	41¶	100	17	41.5

* Of these, 2 were type I (no deaths); 2 were type II (both died); 1 was type III (recovered); 8 were type IV (2 deaths) and 13 were untyped (4 deaths).
† Four of these cultures contained a few pneumococci (2 type IV and 2 untyped) (2 deaths).
‡ One of these cultures contained a few pneumococci (patient died).
§ One of these cultures was Streptococcus hemolyticus, one Streptococcus nonhemolyticus and two were untyped (all died).
¶ The etiology was not recorded in 7 additional cases (2 fatal).

TABLE 3.—*Distribution of Cases and Deaths in Relation to the Presence or Absence of Complications*

Complications	Number of Patients	Case Distribution, per Cent	Number of Deaths	Case Fatality, per Cent
Absent	27	56.2	4	14.8
Present	21*	43.8	15	71.4
Total	48	100	19	39.6

* Of these, 5 had septicemia, 1 septicemia and pneumococcus meningitis, 1 pneumococcus meningitis, 1 pericarditis and pyelitis, 1 myocarditis, 1 erysipelas, 1 abscess of the lungs, 1 bronchiectasis (all 12 of these died); 3 had pneumococcus peritonitis (2 died); 2 had pyopneumothorax (1 died); 2 had measles, 1 diphtheria and 1 varicella (all 4 recovered).

TABLE 4.—*Distribution of Cases and Deaths in Relation to the Type of Operation Performed*

Type of Operation	Number of Patients	Case Distribution, per Cent	Number of Deaths	Case Fatality, per Cent
Rib resection	24	52.2	7	29.2
Trocar and cannula	22	47.8	11	50
Total	46*	100	18	39.2

* The type of operation was not recorded in 2 additional cases (1 fatal).

records from time to time to determine whether methods which are advocated are accomplishing their purpose. The essential difference between these two procedures is that when the trocar and cannula are used the size of the aperture for drainage is sacrificed in order to reduce the amount of operative trauma and also to prevent the leakage of air into the thoracic cavity. Apparently the reason for the lower fatality

rate in the group in which rib resection was performed is that in the latter operation adequate drainage is immediately established and maintained, while when the trocar and cannula are used occlusion of the tube is too easily possible.

COMMENT

Versatility in the application of therapeutic measures to surgical conditions is apt to be attended with success more frequently than is the pursuance of a routine method. This is true, it would seem, of acute empyema. The type of treatment to be employed should depend not only on the age of the patient and the infecting organism but also on the type of disease to which the empyema is a sequel and the stage of the primary disease in which the empyema is recognized as a complication. These are only the more important factors which should aid in the effort to

TABLE 5.—*Percentage of Survival in Relation to the Type of Operation Performed and the Etiology, the Location of the Empyema, the Patient's Physical Condition, His Age, the Presence or Absence of Complications*

	Percentage Who Survived	Percentage with Trocar and Cannula Operation	Percentage of Those with Trocar and Cannula Operation Who Survived	Percentage of Those with Rib Resection Operation Who Survived
Pneumococcus infections	69	48	50	92
Infections with other organisms	40	53	37	43
Right-sided empyema	73	52	64	80
Left-sided empyema	54	42	40	64
Good or fair condition	68	48	73	67
Poor	52	48	27	75
Under 1 year of age	55	55	42	70
Over 1 year of age	65	42	60	71
With complications	29	79	18	0
Without complications	85	34	82	81

determine the method of treating a person with acute empyema. However, in spite of this knowledge, it is not infrequent for a report of some new method of treatment to appear which pretends to embrace the entire field of acute empyemas, without regard for more than perhaps one important factor. New methods are, of course, always to be welcomed, but it seems to us that they should be carefully assigned to the type of case which will receive the maximum benefit from their application.

Before the World War, the type of acute empyema most often noted was that following lobar pneumonia and was caused by the pneumococcus. The pleural effusion in those cases occurs relatively late in the disease process and the involved lung is more or less attached to the wall of the chest by fibrinous adhesions. Thus the thoracic pleura and at the same time the mediastinum are somewhat stabilized. The pneumococcus pus is thick and contains many fibrinous masses of considerable size. In this type of case the open thoracotomy, either a partial rib resection or an intercostal incision and drainage, proved most efficacious.

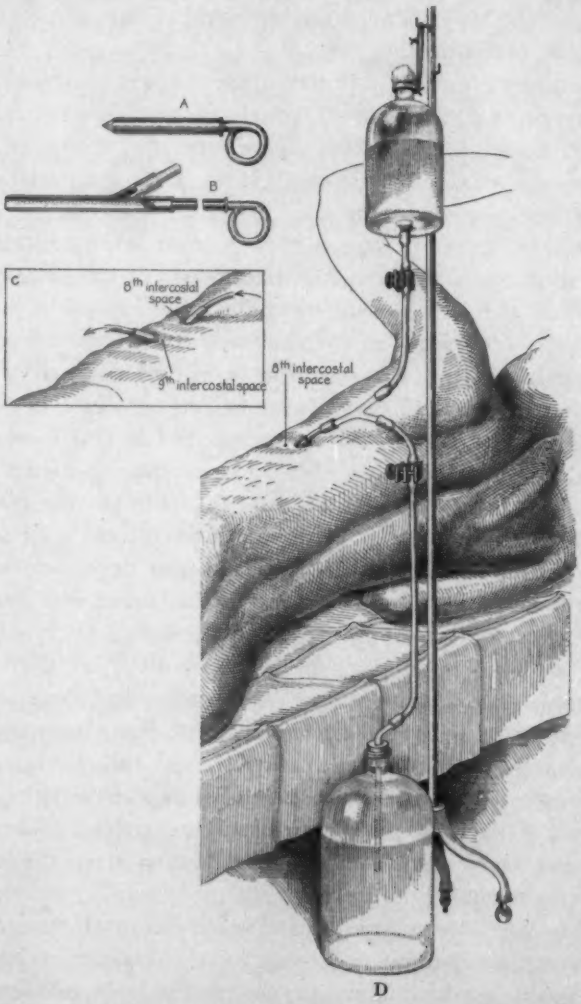
The resulting entrance of air into the empyema cavity did not have any ill effects of itself, because the stage of the pneumonia is not acute, and as mentioned previously, the pleural effusion develops relatively late in the disease. As the affected lung has become stabilized by adhesions, the mediastinum is more immobile. There is therefore little danger that a pneumothorax, associated with the open thoracotomy, will interfere with the expansion of the opposite and nonaffected lung. On the other hand, the maximal amount of drainage is afforded which allows complete removal not only of the pus but of the fibrinous masses. The relatively low fatality rate in this type of case, not only in adults and older children but also, as our statistics (table 5) demonstrate, in infants on whom an open thoracotomy has been performed, is sufficient proof of the efficacy of this procedure. However, the late Dr. John Howland [14] after having performed many autopsies on infants who succumbed to acute empyema at the Babies' Hospital in New York City, came to the conclusion that inability to expand the compressed lung seemed to be an important factor, as a certain amount of pneumothorax was always found at autopsy. Dr. Howland was at a loss to explain why the fatality in infancy was so much higher than in older children or adults, unless it was because of this pneumothorax, and he noted "that many of these children on admission are in fairly good condition and make excellent progress for a week or more after the operation. . . . Then the temperature rises, the patients lose ground rapidly and die of exhaustion during the third or fourth week." The report of the Empyema Commission of the U. S. Army in 1918 [8] demonstrated that the acute empyemas which occurred as complications of pneumonia caused by *Streptococcus hemolyticus,* when treatment was done in the conventional manner, i.e., immediate open thoracotomy with open drainage, were attended with an average fatality of 30.2 per cent and in some districts, of 70 per cent; the highest was 84 per cent in a series of eighty-five patients. As a result of the avoidance of open drainage of the thorax and thus a concomitant pneumothorax, of operation performed at a later stage of the streptococcic pneumonia, to which the empyema was secondary, of closed thoracotomy and then a gradual decompression of the affected pleural cavity, the fatality rate dropped to less than 5 per cent.[8]

The reason for this lower fatality rate is that streptococcic pneumonia is of a different type than lobar pneumonia. In streptococcic pneumonia, according to MacCallum,[15] there is more widespread involve-

14. (Footnote 2.) Personal communication to the authors.

15. MacCallum, W. G.: The Pathology of the Pneumonia in the United States Army Camps During the Winter of 1917-1918, Rockefeller Monograph no. 10, New York, 1919.

ment of the parenchyma of the lungs on both sides. Also, the bronchioles are often obstructed because the infection produces areas of atelectasis with a resulting decrease in oxygenation and an increased dyspnea and cyanosis. A further characteristic of this group of cases is that a pleural exudate occurs early in the stage of the pneumonia when



A, type of trocar and cannula originally used in the Johns Hopkins Hospital. Made by Mont R. Reid and Adrian S. Taylor. *B*, improved type of trocar and cannula used by Rienhoff to prevent suction of air into pleural cavity on removal of trocar from cannula when the tube was inserted. *C*, double drainage of thoracic cavity with larger outgoing than ingoing tube. This was suggested by F. C. Lee to facilitate drainage and reduce the plugging of the catheter and blockage of drainage. *D*, gravity apparatus connected to wall of the chest of the patient.

there are relatively few, if any, adhesions between the lung and the thoracic wall to stabilize the mediastinum. In other words, the open thoracotomy is satisfactory in the treatment of adults with an acute empyema of pneumococcal origin, but in the patients with acute empyemas associated with a streptococcic pneumonia the closed method of thoracotomy is far superior. The determination in adults of at least the etiology and the type of pneumonia should dictate the choice of thoracotomy to be performed.

The results of our study in these cases of acute empyemas in infants under 2 years of age, however, would seem to demonstrate that better results can be obtained by the use of one operation, the open thoracotomy, in all cases. It is evident from our own statistics and from those previously quoted that the resistance and margin of safety in infants under 2 years of age suffering from acute empyema is slight. It would seem to us that the best treatment is immediate and adequate drainage. If the relationship of all of the factors which affect the fatality rate is considered in connection with the type of operation performed (table 5), it is apparent that open thoracotomy (rib resection) offers an infant a much better chance of recovery in every type of case, except possibly in those who are in good or fair condition and in those who develop complications. However, in those patients who are in good or fair condition, the fatality rate is practically the same with each type of operation (table 5). With regard to patients with complications, it is true that all three of the patients who developed complications after the rib re-section died, while two of the eleven who developed complications after the use of the trocar and cannula survived. However, as nearly as we could judge, the great majority of the complications were recognized some time after the operation had been performed, so we are inclined to believe that they resulted from inadequate drainage. As may be seen in table 6, the development of complications is probably the most important factor in case fatality; there is little difference in the chances of survival if complications are absent. Therefore, since complications occur four times as frequently after the closed thoracotomy (trocar and cannula) than after the rib resection, it seems obvious that the latter operation is preferable in all cases.

The open thoracotomy (rib resection) is especially desirable if the empyema is due to the pneumococcus, for the large masses of fibrin do not interfere with the drainage of the cavity as they do with the closed method. Ninety-two per cent of the infants who had pneumococcal infection and on whom rib resection was performed survived in contrast to 50 per cent on whom closed thoracotomy was performed (table 5). In empyema due to other organisms, the effect of the type of operation was unimportant. In other words, pneumococcic infection and rib resection are two favorable factors in producing a low fatality rate. Obviously

the type of infection is beyond human control but, fortunately, pneumococci are responsible for about two thirds of the cases. In the forty cases in which the etiology and the type of operation were recorded, twenty-five were due to pneumococci and fifteen were due to other organisms. If the rib resection had been done in all instances, only two deaths would have been expected among those in whom the infection was of the pneumococcic type (8 per cent) and nine among the remainder (57 per cent), making a total fatality rate of 27 per cent, which would be a marked improvement over the present rate of 40 per cent.

The younger the patient and the poorer his condition, the more important it is to establish free drainage immediately, for, as shown in table 5, the percentage of survival among infants under 1 year of age

TABLE 6.—*Percentage of Survival in Relation to the Presence or Absence of Complications and the Type of Operation Performed, the Etiology, the Location of the Empyema, the Patient's Physical Condition*

	Percentage Who Survived	Percentage with Complications	Percentage of Those with Complications Who Survived	Percentage of Those without Complications Who Survived
Trocar and cannula	50	50	18	82
Rib resection	71	12	0	81
Pneumococcus infections	65	35	33	88
Infections with other organisms	47	53	12	72
Right-sided empyema	73	41	56	85
Left-sided empyema	54	37	11	80
Good or fair condition	68	29	43	77
Poor condition	52	56	23	90

and among those in poor physical condition was respectively two and three times higher when the rib resection was performed than it was after the closed thoracotomy. Yet it was for these younger patients and for those in poor physical condition that the operation in which the trocar and cannula were used was especially recommended!

It is our opinion, that there is little difference in the shock to the infant resulting from the closed or open thoracotomy. Equal amounts of local anesthetic have been used in both types of operation and approximately the same amount of time has been consumed by the two procedures, so that there is little difference between the actual performance of them that would tend to recommend one in preference to the other. Another interesting fact brought out by this study is that the patients were operated on by different surgeons in this hospital from 1915 until 1928, and the case fatality rate was about the same for all. Each operator's technic for the closed and open thoracotomy, together with the preoperative and postoperative care, was almost identical, so that the operation and the postoperative care can be considered almost a constant.

Thus, it seems to us that this series of cases of acute empyema in infants under 2 years of age may be considered a parallel series in which two types of thoracotomy were employed, i. e., the open and the closed method.

CONCLUSIONS

An analysis has been made, in relation to several factors, of the distribution of cases and deaths in a series of forty-eight cases of empyema in infants under 2 years of age, in whom the condition was treated surgically. Five of these factors have a striking effect on the fatality rate, i. e., the fatality rate was highest among infants in poor physical condition, those who had left sided or double empyema, those who had nonpneumococcal infections, those who developed complications and those in whom operation was performed by means of the closed thoracotomy or the trocar and cannula method. It is, of course, obvious that the patient's physical condition and the presence of complications should play rôles in the fatality rate, but, as far as we know, it has not been demonstrated in young infants that the location of the empyema, the etiology and the type of operation were as important as our tables would seem to indicate. A knowledge of the effect of four of the five factors is merely an aid to prognosis, but it seems to us that the higher fatality rate among infants in whom the closed thoracotomy (trocar and cannula) was performed is of therapeutic significance and should, if other studies confirm our figures, lead to the abandonment of that operation in the treatment of infants under 2 years of age with empyema.

It is our impression that in infants open thoracotomy (rib resection) is on the whole a more satisfactory procedure than closed thoracotomy (in which the trocar and cannula were used) mainly because an immediate, uninterrupted free drainage of the affected pleural cavity is accomplished. We feel that the slight blocking which often occurred in the closed thoracotomy was in all probability mainly responsible for the marked increase in complications associated with this procedure. Owing to the fact that a lateral intercostal incision is so frequently associated with a pinching and occlusion of the rubber drainage tube, the partial rib resection is the method of open thoracotomy to be preferred. A partial pneumothorax resulting from the open thoracotomy is apparently less dangerous than is the inadequate drainage associated with the closed thoracotomy.

THIRTY-SIXTH REPORT OF PROGRESS IN ORTHOPEDIC SURGERY*

PHILIP D. WILSON, M.D.
LLOYD T. BROWN, M.D.
M. N. SMITH-PETERSEN, M.D.
RALPH GHORMLEY, M.D.
AND
MURRAY S. DANFORTH, M.D.
BOSTON
AND
HERMAN C. BUCHOLZ, M.D.
HALLE, GERMANY

(Concluded from page 534)

TUMORS

Synoviatoma.—Under the name of synoviatoma, Smith [34] reported a group of three unusual tumors which appeared to originate from synovial membrane or similar tissue. In the first patient the tumor arose in the fascia in Hunter's canal, and the patient died at the end of six months supposedly from pulmonary metastases. Microscopically, the tumor was composed of anastomosing clefts lined by low cuboidal epithelium and separated by cords of spindle shaped cells. The second patient was a Jewess, aged 24, with a tumor extending down the thigh under Poupart's ligament. She died at the end of three years of pulmonary metastases. The third patient was a man of 35, with a tumor on the inner side of the knee. Death resulted at the end of two and one-half years, again from pulmonary metastases. The tumors in these cases were similar to that in the first. According to the author, this type of tumor may arise from the synovial membrane of the cavity of the joint itself, from the synovial membrane of overlying bursae, from fascial aponeurosis and from tendons and tendon sheaths. Two types of cells can be differentiated, the synovial lining type and the stroma type.

Tumors of Tendon Sheaths.—From the surgical clinic of the John Casimir University of Dwów, Poland, Janik [35] reported details of four

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* This Report of Progress is based on a review of 258 articles selected from 419 titles dealing with orthopedic surgery appearing in medical literature between Sept. 24, 1927, and Feb. 25, 1928. Only those papers that seem to represent progress have been selected for note and comment.

34. Smith, L. W.: Am. J. Path. **3**:355 (July) 1927.

35. Janik, Alfred: Ann. Surg. **85**:897 (June) 1927.

cases of tumors of the tendon sheaths and stated the results of a review of various groups of similar tumors reported in the literature. His summary follows:

1. Primary tumors of tendons are very rare. The commonest of them are the sarcomata.

2. Primary tumors of tendon sheaths are more frequent. The commonest among them are the giant-myelomata (granulomata).

3. The giant-celled myeloma seems to be caused by some injury or irritation. It is an inflammatory granuloma, and should therefore, be excluded from the group of neoplasms and included in that of inflammatory disease.

4. The following classification and terminology of the tumors of tendons and tendon sheaths should be adopted: *A.* Neoplasms: I. Neoplasms of tendons; (1) Benign neoplasms: fibroma, osteoma, chondroma; (2) Malignant neoplasms: sarcoma. II. Neoplasms of tendon sheaths; (1) Benign neoplasms: fibroma, lipoma, chondroma, angioma; (2) Malignant neoplasms: sarcoma; (3) Mixed neoplasms. *B.* Inflammatory and other tumors: tendovaginitis tuberculosa: granuloma (the former myeloma), ganglion, etc.

5. The differential diagnosis between the tumors of tendon sheaths and inflammatory diseases, especially tendovaginitis tuberculosa granulosa, is difficult.

Endothelial Myeloma (Ewing's Tumor).—Sycamore and Holmes [36] reviewed the subject of endothelial myeloma, finding the incidence of this neoplasm probably as about 10 per cent of tumors of the bones. They concluded from their studies that the condition should be sharply differentiated from angio-endothelial and from osteogenic sarcoma and that it should be possible to recognize the tumor in spite of the fact that in their own experience the diagnosis has been more often missed than made. The tumor responds strikingly to roentgen-ray or radium therapy, but the prognosis is poor because of the frequency of metastasis.

Tumors of the Cervical Spine.—Camurati [37] collected reports of eighteen cases of primary giant cell tumors of the cervical spine. To these he added one case report from the Anatomical Museum and Clinical Archives of the Rizzoli Institute. Judging from the diverse opinions of many authorities, he believed that it is impossible to establish whether the nature of the process is neoplastic or an inflammatory reaction to agents of varied nature (trauma, toxins, etc.). Some authors believe that following hemorrhage in the confines of the osseous medulla, the tissues destined to form the medulla itself proliferate and form a true cellular zone in the hemorrhagic field. Thus there may be formed a fibrous tissue to surround it or invade it, transforming the coagulum into a cicatrix. In other cases the tissue that is formed subsequent to a hemorrhage from trauma may continue to grow until a tissue results that is similar to that of tumors with giant cells. This granular tissue

36. Sycamore, Leslie K., and Holmes, George W.: Am. J. Roentgenol. **18**:223 (Sept.) 1927.

37. Camurati, M.: Chir. d. org. di movimento **6**:581 (Nov.) 1927.

containing giant cells is found sometimes in pseudarthroses, in formation of callus and sometimes in Köhler's disease. Such tissues can be histologically similar to a tumor with giant cells, while biologically they must be considered as a chronic process of repair.

Tumors of Cauda Equina and Spinal Cord.—Bennett [38] reported four cases of tumors of the spinal cord and cauda equina, in each of which the symptoms suggested osseous, muscular and ligamentous disturbances rather than pathologic changes in the nervous system. The tumors were revealed either at operation or at autopsy. The most prominent symptoms in these cases and the ones which the author believes point strongly to this condition are: (1) variable pain in the spine and nerve roots; (2) extreme spasm of the erector spinal muscles followed by lateral deformity of the spine, and (3) extreme bilateral spasm of the hamstring group. All these signs appeared long before any motor or sensory changes occurred.

[ED. NOTE.—The significance of Bennett's article is that the symptoms of tumor of the spinal cord or cauda equina may, at least in the early stage, be indistinguishable from those of ordinary back strain. When the nervous system is examined, however, signs will usually be found pointing to the true nature of the lesion. Numerous instances are on record of patients with such tumors being treated for back strain over considerable intervals of time before the correct diagnosis was made. The only method by which the orthopedic surgeon may avoid such errors is to examine the nervous system in all patients with pain in the back.]

TUBERCULOSIS

Results of Treatment of Tuberculosis of the Hip.—Smith and Watters [39] recently completed a study of 208 patients who were treated for tuberculosis of the hip at the Country Branch of the New York Orthopaedic Dispensary and Hospital. Only nonoperative methods of treatment were employed. In this group, the diagnosis was found to have been wrong in forty-six, or 22 per cent of the patients. The only way to eliminate such errors is by aspiration or exploratory operation to obtain material for pathologic investigation and inoculation into guinea-pigs. Of 150 patients who were followed for three years or more, thirty-six, or 24 per cent, died, the majority of tuberculosis. In seventy-one patients, or 47 per cent, the tuberculous process in the hip was found to be still active. In forty-one patients, or 27 per cent, the process was found to be quiescent, with little if any motion in the hip

38. Bennett, George E.: Tumors of Cauda Equina and Spinal Cord, J. A. M. A. **89**:1480 (Oct. 29) 1927.

39. Smith, Alan DeForest, and Watters, W. H.: Tuberculosis of Hip, J. A. M. A. **90**:189 (Jan. 21) 1928.

and some degree of deformity. Only two patients were found who were entirely free from symptoms and who showed a useful range of motion.

Comparative Results of Operative and Nonoperative Treatment of Pott's Disease in Children.—After a trial of nonoperative and operative methods in the treatment of Pott's disease in children, Kidner and Muro [40] concluded that operation ought not to be performed except in selected cases and that the best treatment is absolute recumbency on a Bradford frame, under favorable environment until bony union of the diseased vertebrae is clearly demonstrable by roentgen-ray examination. The authors divided a series of fourteen cases into pairs and performed fusion operations in the alternate cases and treated the other patients without operation. From the observation of these patients, they concluded that cure depends on prolonged recumbent treatment, that cure in the patients operated on requires as long a period of time as in the patients not operated on and that the patients who are treated without operation preserve greater flexibility of the spine.

Tuberculosis of the Knee in the Adult.—Henderson and Fortin [41] studied the end-results of 211 adult patients with tuberculosis of the knee joint who were treated by resection at the Mayo Clinic. The diagnosis of tuberculosis was proved in all cases. The signs and symptoms of chief importance and the ratio in which they were present were as follows: pain, 99 per cent; stiffness, 100 per cent; limp, 99 per cent; swelling, 97 per cent, and local heat, 53 per cent. As for roentgen-ray examination, the authors stated that they do not believe that there is a typical picture for tuberculosis of the knee. Evidence of involvement of the bone was found in all but 9.87 per cent. The "bone abscesses" were usually found in the inner condyle of the femur or in the inner tuberosity of the tibia. A method of resection developed by the authors was employed in all cases. This consists of an excision of the surfaces of the joints of the tibia and femur, together with an excision of the synovia and patella. A graft consisting of a layer of the cancellous bone is laid along the anterior surface of the joined bone ends, under "leaves" of bone lifted from the front of the tibia and femur. Two wire nails are driven up through the tibia into the femur to hold the ends in apposition. The leg is then fixed in a plaster casing extending to the groin. In 194 patients who were followed, operative mortality did not occur. Two patients died of tuberculous meningitis within one year, and 8.7 per cent died within four years. Amputation became necessary later in 2.5 per cent. Nonunion resulted in 11.3 per cent, but of these patients four later obtained fusion by bone grafting operations. Dis-

40. Kidner, F. C., and Muro, Felipe: J. Bone & Joint Surg. **9**:649 (Oct.) 1927.

41. Henderson, M. S., and Fortin, Harry J.: J. Bone & Joint Surg. **9**:700 (Oct.) 1927.

charging sinuses still remain in 2.06 per cent of the patients. In 23.7 per cent tenderness was present, usually along the scar. Primary bony union was obtained in 88.3 per cent. The authors state that with their present technic (graft) they expect to obtain firm union in from five to eight months.

Quantitative Tuberculin Reaction.—After a discussion of allergy, on which the tuberculin reaction is based, Atsatt [42] stated that by means of a special quantitative examination it is possible to determine approximately the activity of tuberculous foci. Using the same lot of Saranac tuberculin throughout the series, he injected intradermally 1 cc. of old tuberculin in dilutions of 1:1,000, 1:2,500, 1:5,000, 1:7,500 and 1:10,000. Because of the degree of the skin reaction or of the fluctuation of allergy in direct proportion to the activity of the disease, the author found that by establishing a critical threshold (in this series, a dilution of 1:7,500), active tuberculosis could be diagnosed with a fair degree of certainty. The test was employed in patients with tuberculous and nontuberculous lesions of the bones and joints, on whom operation was later performed and the opportunity thus afforded of verifying the tests by examination of pathologic material.

[ED. NOTE.—We have had the opportunity of seeing Atsatt's quantitative tuberculin reaction employed at first hand in a series of more than 100 cases. We are convinced that it is a more reliable test of tuberculosis of the bones and joints than the ordinary tuberculin skin test.]

Effect of Rachitogenic Diet on Experimental Tuberculosis.—Grant, Suyenaga and Stegeman [43] succeeded in demonstrating experimentally that white rats can be made susceptible to inoculation of tuberculosis by decreasing the calcium and vitamin D content of the diet. The animals developed tuberculosis of the lungs, which was proved by pathologic examination and inoculation into guinea-pigs. Control rats which received an adequate diet before and after subcutaneous inoculation with tubercle bacilli remained immune even after relatively large doses.

Rice Bodies in Tuberculosis.—Rogers [44] reported the case of a patient with tuberculous tenosynovitis who showed the presence of numerous rice bodies. The diagnosis was proved by the examination of material removed at operation. The process of formation of the rice bodies could be followed in the tissues, and from a study of the pathologic material the author stated that it was apparent that the rice bodies represent the centers of tubercles.

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42. Atsatt, Rodney F.: J. Bone & Joint Surg. **9**:657 (Oct.) 1927.

43. Grant, A. H.; Suyenaga, B., and Stegeman, D. E.: Am. Rev. Tuberc. **16**: 628 (Nov.) 1927.

44. Rogers, Mark H.: J. Bone & Joint Surg. **9**:636 (Oct.) 1927.

Synovial Tuberculosis.—Peabody [45] described five patients with tuberculous lesions of the joints which seemingly involved only the synovial structures, and expressed the opinion that they establish the fact that tuberculosis may exist solely as a lesion of the synovia. His observations are summarized as follows: Five patients suffering from a chronic disorder of the joints of from two to seven years' duration presented physical manifestations inconsistent with those commonly looked for in established tuberculosis of the joints, and roentgen-ray examination was negative for destruction or absorption of bone. Operation was performed in all of the cases, and the pathologic condition found was that of long standing tuberculosis distributed throughout the synovial membrane and unaccompanied by any lesion of the bone. Four of the patients were adults between the ages of 23 and 31, in excellent general health and free from constitutional stigmas of tuberculosis. In none did a preoperative diagnosis of tuberculosis of the joints seem to have clinical support.

[ED. NOTE.—It seems to us that the evidence adduced by the author is insufficient to justify his conclusions.]

PYOGENIC INFECTIONS

Pathogenesis and Treatment of Acute Epiphysitis.—Wilensky [46] expressed the belief that in acute epiphysitis the dominant characteristics of the pathologic picture are (1) a thrombo-arteritis or thrombophlebitis and (2) a necrosis of bone and cartilage cells consequent to the disturbance of circulation produced by the plugging of the vessels. Clinically, he divided the cases of acute epiphysitis into three groups: 1. In the first variety, a focus is present in one of the epiphyses with well marked local signs and symptoms, but without any clinical signs of a general blood infection. 2. In the second variety, a well marked focus is present in one of the epiphyses with abundant local signs and symptoms and, in addition, there are clinical indications of a bacteremia as evidenced by the general signs and symptoms and by the demonstration of living bacteria in the blood stream. 3. In the third variety the clinical picture is that of a profound general infection with a marked toxemia. A local focus is either not demonstrable at all because of the paucity of local signs and symptoms or because the latter is concealed by the profound intoxication, or, if present, the local lesion is easily recognized as not being of any consequence in the total clinical picture. Blood cultures are of assistance in determining the severity of the lesion and in suggesting the appropriate treatment. In the absence of a demonstrable bacteremia, conservative treatment is desirable, other things

45. Peabody, Charles E.: Ann. Surg. **86**:92 (July) 1927.

46. Wilensky, Abraham O.: Ann. Surg. **86**:105 (July) 1927.

being equal, and later a minor operation alone may be indicated. In the presence of a demonstrable bacteremia and a definite focus, elimination of the focus is indicated, as little damage as possible being done. In the fulminating types, even with a demonstrable focus, the prognosis is always grave, with little help from operative procedures.

POLIOMYELITIS

Experimental Immunization.—The results of experiments on monkeys to produce immunity to poliomyelitis have been reported by Aycock and Kagan.[47] Pointing out that one attack of the disease confers lasting immunity and that the blood serum of convalescent patients is virucidal, the authors stated that attempts so far to increase the penetration of the serum in the central nervous system and to develop a hyperimmune serum have been unsuccessful. Killed virus does not have immunizing power. Experiments have been made with an attenuated virus which had been treated with phenol, 0.25 per cent to 1 per cent and diluted with glycerin, 5 to 50 per cent. The results were variable, and a vaccine which was effective in producing immunity was still virulent enough to kill from one third to one half of the monkeys used. With subcutaneous inoculation, less than one half of the animals developed the disease. Of two animals inoculated by scarification, one developed the disease and the other died of tuberculosis. Repeated intracutaneous injection produced infection in a small number of monkeys and protected the remainder from repeated cerebral inoculation of virus or prolonged the incubation time. Of twelve monkeys so treated, one developed the disease, two resisted three intercerebral inoculations, two resisted two such inoculations, three resisted one inoculation, and one showed prolongation of the incubation period.

Control of Infection.—Discussing the control of poliomyelitis, Ebright [48] stated that the disease is spread chiefly by direct contact with people who harbor the virus in the nose and mouth. These people may be developing the infection or they may be carriers or convalescents. Infection takes place by the mouth, nose, conjunctiva of the eye and the tear duct and stomach. Prevention of spread of the infection is to be accomplished by adequate bedside precautions. There is no evidence that regulations against the congregation of people has any influence. All discharges from the nose, throat and bowel should be disinfected. Caretakers, nurses and physicians should guard against infection from contamination with discharges or secretions on hands and clothing. Patients should be thoroughly bathed, the hair included, on the termination of isolation, which should last for from two to three weeks. Com-

47. Aycock, L., and Kagan, J. R.: J. Immunol. **14**:85 (Aug.) 1927.

48. Ebright, G. E.: California & West. Med. **27**:354 (Sept.) 1927.

munities should encourage public health nurses to teach precautions in the home. Expert diagnosticians should be employed during epidemics, and cases should be promptly reported.

BOOK REVIEW

Poliomyelitis.—MacAusland [49] has written probably the best textbook on poliomyelitis that is available at present. It brings to date the knowledge on history, epidemiology, etiology, pathology and treatment of the disease in the acute stage. The chapter on the epidemiology is particularly valuable, because of the extensive collection of epidemics described. There is some inconsistency in respect to the length of time during which improvement may be expected to take place. In one place six months is given as the maximum time, while elsewhere, it is stated that operation should not be performed until after the lapse of two years because of the improvement that may take place. The surgical treatment is discussed at length, with good operative illustrations. The author is an ardent advocate of astragalectomy and reports 400 cases, with twelve failures, as against six cases of stabilization of the foot by subastragalar arthrodesis. Also, more space appears to be devoted to tenodesis and Whitman's loop operations than the value of these procedures seems to justify. The author has attempted to standardize the surgical treatment, always a difficult thing in as variable a condition as poliomyelitis, and the reader is left in considerable doubt as to what procedure to follow in the various conditions.

VASCULAR DISEASES

Spontaneous Gangrene.—Discussing the pathology of the different types of gangrene of the extremities, Lewis [50] divided these conditions into: (1) arteriosclerotic gangrene; (2) arteriosclerotic gangrene with glycosuria (diabetic gangrene), and (3) thrombo-angiitis. In all of these conditions, the development of a collateral circulation is of prime importance. Lewis recommended ligation of the femoral artery, which he has performed in seven cases. One death, two cases in which amputations were performed later and four in which improvement occurred were noted in this series.

Erroneous Diagnosis.—Allen and Brown [51] pointed out that the diagnosis of vascular diseases is comparatively easy in 90 per cent of the cases, but that in the remaining 10 per cent there is a high incidence of error. They reported in detail the conditions found microscopically in tissues obtained in eight cases which had been diagnosed as Raynaud's disease but which on pathologic investigation were shown to be cases

49. MacAusland, W. R.: Poliomyelitis, Philadelphia, Lea & Febiger, 1927.
50. Lewis, Dean: Canad. M. A. J. **17**:1125 (Oct.) 1927.
51. Allen, E. V., and Brown, G. E.: Am. J. M. Sc. **174**:319 (Sept.) 1927.

of obliterative vascular disease. They stated that a complete obliteration of the palpable vessels is not essential for a diagnosis. In approximately 5 per cent of patients with thrombo-angiitis obliterans the pulsations in the dorsalis pedis and posterior tibial arteries were normal. In these cases, the occluding vascular lesion involved the digital or interosseous arteries.

Diagnosis.—The accompanying table shows the classification of vascular diseases suggested by Brown and Henderson.[52]

The basic disturbance is similar in all forms of vasospastic disease, i.e., Raynaud's disease, acrocyanosis, etc. The essential points in the diagnosis of functional disorders are: (1) open palpable arteries with

Classification of Vascular Diseases (Brown and Henderson)

Functional or vasomotor types	Local distribution	Vasoconstricting types	1. Multiple phase color reaction: Raynaud's disease
			2. One phase color reaction–acrocyanosis; dead finger; local syncope
		Vasodilating types	Erythromelalgia
	General distribution	Vasoconstricting types	Primary or essential hypertension, early stages
		Vasodilating types	Primary or essential hypotension
Organic types	Local Distribution		1. Arteriosclerosis with or without thrombosis: diabetic gangrene
			2. Thrombo-angiitis obliterans
			3. Simple thrombosis or embolism
			4. Arteritis of known infectious origin (rheumatic-syphilitic)
			5. Aneurysm with or without thrombosis
	General distribution	Arteriosclerosis	
		1. Primary	
		2. Secondary to hypertension	

pulsation; (2) intermittent changes in color and temperaure; (3) distribution usually in all four extremities. Erythromelalgia (Weir Mitchell) is functional and nonprogressive and is relieved by cold and elevation of position. These changes may to a less degree accompany the organic types of disease. Thrombo-angiitis obliterans as a disease entity is discussed. The authors pointed out that Rabinowitz isolated an organism from patients and succeeded in producing vascular disease in rabbits. Tobacco, race, age, sex (male) and exposure to cold are considered as contributing factors. Fifty-one per cent of the authors' patients showed claudication as an initial symptom (claudication after exertion). With

52. Brown, George E., and Henderson, M. S.: J. Bone & Joint Surg. **9**:613 (Oct.) 1927.

the onset of trophic changes, "rest pain" occurs in contradistinction to claudication or "exercise pain." The disease is usually bilateral. The arteriosclerotic type of disease is well understood, but the differential diagnosis in men between the ages of 45 and 55 is sometimes difficult. In discussing the treatment, the authors mentioned various prophylactic and reassuring measures. In Raynaud's disease of the lower extremities, lumbar sympathetic ganglionectomy is said to be curative. A useful table for differential diagnosis is included.

Collateral Circulation.—Bernheim and Sachs [53] showed that in obstructive vascular disease of the extremities, such as arteriosclerosis and thrombo-angiitis obliterans, there is a definite increase in the number and size of the blood vessels of the sciatic nerve, both in the perineural tissue and within the fasciculi as well. These symptoms are constant. This increased vascularization accounts for the survival of certain limbs long after their main blood vessels have become totally occluded. Moreover, whatever the degree of the obstructive process in the main blood channels, the sciatic vessels do not appear to be similarly involved other than by by some thickening of their walls and a certain amount of calcification. Thrombosis of the sciatic vessels has not been observed in the author's experience.

Ramisection.—Discussing the surgical treatment of Raynaud's disease and similar conditions, Royle [54] pointed out that with the adoption by Lerche of ramisection, practically the only line adopted is now by means of ramisection or ganglionectomy of the sympathetic nervous system. The surface temperature is thereby increased from 2 to 7 degrees and the heat production from 200 to 900 per cent. Since the vasoconstrictor fibers reach the segmental nerves by the gray rami, it is only necessary to cut these and not to remove the whole abdominal sympathetic trunk. Of eight patients on whom ramisection was performed by the author, four with thrombo-angiitis had only temporary relief from pain but showed more or less permanent improvement in the condition of the limb. In the patients with Raynaud's disease the results were much more satisfactory, and three out of four were completely relieved. The fourth patient had involvement of the upper limb, while in all the others the lower was involved.

DISTURBANCES OF THE NERVOUS SYSTEM

Pathology of Charcot Joints.—From a study of the pathologic changes in Charcot's joint, Potts [55] pointed out that neuro-arthropathy may affect any joint in the body. Two conditions must obtain: a change

53. Bernheim, B. M., and Sachs, L.: Ann. Surg. **86**:417 (Sept.) 1927.
54. Royle, N. D.: M. J. Australia (supp. 11), Nov. 5, 1927, p. 341.
55. Potts, W. J.: Ann. Surg. **86**:596 (Oct.) 1927.

in the sensory nerves and trauma to the joint. As long as the existence of trophic nerves is unproved, there is no reason to believe that this condition results from anything but the destruction that follows in a joint which lacks its protective muscular mechanism. When the bones are deprived of the accurate weight distributing power of the muscles and of the stabilizing protection afforded by an intact reflex nervous mechanism, minor stresses are bound to produce damage. So-called spontaneous fractures in tabetic patients commonly occur for the same reason. According to this hypothesis, neuropathic joints are simply variable pictures of destruction and erosion and of nature's attempt to stop the damage by sclerosis and to repair the damage by building up new bone. The bizarre pictures are the result of the excessive rapidity of both processes.

Brachial Plexus Paralysis.—According to Giliberti,[56] brachial plexus paralysis forms the second largest group of birth palsies. It occurs more frequently after births in which artificial aid is required. The cause is pressure or traction on the brachial plexus. The nerve fibers and bundles may be torn at any point. The Duchenne-Erb or upper arm type of paralysis is the most common and has the best prognosis. The Klumpke-Dejerine or lower arm type is often the residual of a combination type. In this type, sensory symptoms are usually present. The prognosis is less favorable in brachial paralysis than in ordinary injuries of the peripheral nerves. There is a danger in long existent cases that habit palsy may replace organic lesions. Treatment consists in immediate immobilization in abduction, with the forearm in full supination. If regeneration is not evident after physiotherapy has been tried for one year, then resort should be had to neurosurgery. Contractures are best overcome by methods of gradual correction.

[ED. NOTE.—If operation on the plexus is to accomplish the most, it must be performed as soon after injury as possible. Obstetric paralysis is likely to cause such severe crippling in adult life that every emphasis should be placed on early diagnosis and immediate surgical treatment. We do not agree with Giliberti that one should wait a year before resorting to operative treatment. Orthopedic treatment is important and should not be neglected, but it cannot restore severed nerves or prevent cicatricial contraction about the plexus.]

Spontaneous Recovery of Deformity of the Foot Following Laminectomy for Spina Bifida Occulta.—Kochs [57] reported the case of a patient with increasing paralytic equinus deformity of the foot, who was completely relieved by laminectomy for spina bifida occulta. A plate of bone which appeared to press on the cauda equina was found at

56. Giliberti, V.: J. Nerv. & Ment. Dis. **66**:449 (Nov.) 1927.
57. Kochs, J.: München. med. Wchnschr. **74**:1877, 1927.

operation, and there were fibrous bands which bound the nerves together. Following the operation, the vasomotor disturbances immediately disappeared, and active motion soon returned in the paralyzed dorsiflexor muscles of the foot.

[Ed. Note.—Generalization cannot be made from the report of one case, but this article seemed to be of more than casual interest as affording a contrast to the usual pessimistic reports of the results of laminectomy in patients with similar conditions.]

End-Results of Ramisection in Spastic Paralysis.—By an ingenious set of graphic records of the gaits of patients with spastic paralysis, Stewart [58] was able to demonstrate improvement in all of twenty-seven patients subjected to the operation of sympathetic ramisection. Rigidity was reduced, coordination improved and equilibration made better. A direct effect in relieving muscular weakness was not noted.

MISCELLANEOUS

Development of Bone in Diabetic Children.—Roentgenograms of the skeleton in sixty-eight children under the age of 15 years with diabetes mellitus have been reviewed by Morrison and Bogan.[59] It was found that the epiphyseal development and growth of the shaft was in advance of the chronologic age in children with diabetes of recent onset. The development of bone was below the chronologic age in children with diabetes of long standing. Narrowness of the shaft and thinness of the cortex characterized long standing diabetes. Atrophy of the bone was found to occur in a certain number of children who developed diabetes before the age of 9 years.

Physiology of Bone in Relation to Diseases of the Bone.—Discussing the physiology of bone, Eising [60] said that the old idea that growth of bone tissue is a product of osteoblastic or osteoclastic activity must account not only for normal bone production but for the aberrations of the function presented in disease, including the reactions to bacterial or other invasions and tumors. He expressed the opinion that one should accept as a first premise the conception that the vital substance of bone is the collagenous intercellular material. The problem then at once falls within the domain of the chemistry of colloids. Preosseous tissue is devoid of blood vessels to such a degree that it forces the inference that the salts of lime, namely, calcium phosphate and calcium carbonate, must be an inherent part of the collagenous matrix. If one believes that the intercellular substance of bone contains in its substance the specific elements of bone, it becomes easy to conceive how by biologic activity

58. Stewart, Steele F.: J. Bone & Joint Surg. **9**:742 (Oct.) 1927.
59. Morrison, L. B., and Bogan, I. K.: Am. J. M. Sc. **174**:313 (Sept.) 1927.
60. Eising, E. H.: Am. J. Surg. **3**:367 (Oct.) 1927.

spoken of as "calcium coagulation" formation of bone might readily be established. Examples of such biologic colloid mutations are found in the development of the teeth, of the exoskeletons of animals, and probably in the formation of gallstones and other concretions. The property of reversibility which is peculiar to colloids would amply explain the destructive processes of bone absorption and osteolysis. This conception would therefore give the place of first importance to the collagenous intercellular matrix and regard it as a tissue that retains its vitality and holds in a reversible colloidal state the inorganic salts of bone. Any influence, whether chemical, bacterial, vascular, nervous or glandular, would exert its effect on this substance, which in turn would be reflected in a corresponding alteration in the calcified content.

After referring to the work of R. Robison, who has shown that an ester plays an all important part in the conveyance by the blood of calcium with which it forms soluble salts, Fairbank [61] called attention to the field which this discovery opens. For normal development of bone three things appear to be necessary: (1) a proper cartilaginous or membranous scaffold for the bone; (2) the deposit of the necessary inorganic salts; (3) a sufficient number of normal bone forming cells. The author suggests the following classification of general diseases of the bone: I. Congenital developmental errors; osteogenesis imperfecta; diaphyseal aclasis; dyschondrophasia; achondroplasia; craneocleido dysostosis; myositis ossificans idiopathica. II. Errors of metabolism; scurvy; rickets; renal dwarfism; dwarfism associated with (1) celiac disease; (2) pancreatic disorder; (3) hypertrophic cirrhosis of the liver. III. Endocrine errors; gigantism; acromegaly; mollities ossium; osteomalacia; dwarfism and infantilism of various types. IV. Conditions of unknown origin; fibrocystic disease; leontiasis; osteitis deformans; arachnodactyly. V. Multiple neoplasms.

Graphic Records of Normal and Pathologic Gaits.—Schwartz and Vaeth,[62] feeling that a more accurate knowledge of normal and pathologic gaits is essential for the better treatment of persons with deforming limps, invented a mechanical device called a "basograph," with which they can make records of limps for study and comparison with the records of supposedly normal persons. The information obtained thus far by means of these records seems to indicate the value of the machine.

Limps Caused by Diseases of the Hip.—Fairbank [63] classified hip limps as follows: (1) The short leg limp; (2) the painful limp; (3) the stiff limp; (4) the weak leg limp; (5) the hysterical or functional limp.

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61. Fairbank, H. A. T.: Brit. J. Surg. **15**:120 (July) 1927.

62. Schwartz, R. P., and Vaeth, William: Method of Making Graphic Records of Normal and Pathologic Gaits, J. A. M. A. **90**:86 (Jan. 14) 1928.

63. Fairbank, H. A. T.: Lancet **1**:19 (Jan. 7) 1928.

End-Results and Follow-Up in Orthopedic Surgery.—Rogers [64] devised a system by means of which orthopedic patients at the Massachusetts General Hospital, could be followed and the end-results studied; this system has functioned with a high degree of success during a period of three years. The clinics in which the end-results were studied one year, two years and three years after operation have been well attended; the proportion of patients reporting, including many who lived at a distance, has been nearly 80 per cent. The author described the system in detail and presented illustrations of the various forms and tables showing the results obtained. The system promotes greater cooperation between the patient and the orthopedic surgeon in the after-treatment in operative cases, and hence insures better results.

[ED. NOTE.—There is a great need in orthopedic surgery for precise knowledge as to the results of the various operative procedures. Facts must replace impressions to as large an extent as possible. The end-result clinic is the mechanism by which such facts are to be obtained. Having observed the working of Rogers' end-result system at first hand, we take the liberty of expressing the opinion that it is admirably devised to accomplish its purpose.]

Painful Shoulder.—After a review of 450 roentgenograms, which had been made because of a complaint of pain in the shoulder, and ascertaining that the symptoms were negative in 300, King and Holmes [65] were led to make a clinical study from which they drew the following conclusions: The shoulder joint is dependent for its strength on the tone of the muscles which have their insertion in the capsule. Atrophy of these muscles is followed by relaxation and chronic strain. The thinness of the capsule, together with the proximity of bursae, tendons and bones, results in any infection which is primary in one structure soon spreading and involving others. Most persons are subject to constant irritation of their subcoracoid bursae as a result of posture. Limitation of external rotation is more characteristic of subcoracoid bursitis than of any other lesion of the shoulder. It is difficult to rule out a diagnosis of arthritis merely from negative roentgen-ray examination. Extra-shoulder lesions are a common cause of painful, and at times stiff, shoulders. Relaxed capsule is a frequent cause of stiff and painful shoulders. Physical therapeutic measures to counteract atrophy should be instituted at an early period in all cases. Inflammation of many of the structures surrounding the shoulder joint occurs in almost all painful shoulders, and a diagnosis of periarthritis is legitimate when the primary etiologic agent is obscured.

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64. Rogers, William A.: J. Bone & Joint Surg. **10**:104 (Jan.) 1928.

65. King, Jennings M., Jr., and Holmes, George W.: Diagnosis and Treatment of Four Hundred and Fifty Painful Shoulders, J. A. M. A. **89**:1956 (Dec. 3) 1927.

Treatment of Tennis Elbow.—Mills [66] pointed out that many patients with tennis elbow have been relieved by osteopaths, bone setters, etc. The author observed in this condition that full pronation with complete wrist and finger flexion caused limitation of extension of the elbow. By manipulating the elbow into complete extension with the hand and forearm in this position, while at the same time pressing over the external epicondyle, the author was able to relieve the symptoms in all patients so treated. In patients with symptoms of long standing, the author advocated the same manipulation, only with the aid of an anesthetic. He regarded the condition as due to the impingement of a torn part of the orbicular ligament between the radial head and the capitellum, thus simulating displaced semilunar cartilage of the knee joint.

[ED. NOTE.—We do not agree with the author's interpretation of the pathologic condition of tennis elbow, and we are inclined to believe him overenthusiastic as to the results of manipulative treatment. If manipulation proves of value, the explanation is likely to be found in the stretching of inflamed and contracted tissues in the region of the epicondyle.]

OPERATIONS ON THE BONES, JOINTS AND TENDONS

Repair of Nerves and Tendons of the Hand.—Bunnell [67] reported an unusually interesting series of cases of repair of nerves and tendons in the hand. Thanks to a meticulous technic and painstaking study of the disabilities, he was able to secure a high percentage of successful results. His technic is rigidly aseptic and atraumatic. The work is done under ischemia to furnish perfect vision and to avoid the trauma of sponging. "After winding the limb with an Esmarch bandage from the fingers to the elbow, a blood pressure band is placed on the upper arm and pumped to 250 millimeters of mercury. All of the dissecting and fine work is completed before the tourniquet is released, and this should not be longer than one hour, or some degree of induration and reaction will result. On releasing the tourniquet firm pressure is made with sponges on the wound until hemorrhage from the smaller vessels has stopped. Triple O catgut controls the rest." For joining tendons, Turner's patent ligature silk is used. Bunnell reported success with long free grafts of nerves and tendons.

An Operation for Slinging a Dropped Shoulder.—Henry [68] described an operation which he has performed for the relief of paralysis of the trapezius muscle with dropping of the shoulder. The scapular border was exposed and two holes drilled in it. From these holes fascial slings were passed around the spinous process of the sixth cervical and second

66. Mills, Percival: Brit. M. J. **1**:12 (Jan. 7) 1928.
67. Bunnell, Sterling: J. Bone & Joint Surg. **10**:1 (Jan.) 1928.
68. Henry, Arnold K.: Brit. J. Surg. **15**:95 (July) 1927.

dorsal vertebrae, making two loops of fascia between the scapula and the spinal column. An excellent result was obtained in the one patient treated.

Treatment of Coxa Vara.—The treatment of persons with coxa vara was discussed by Riedel, Rost and Koenig,[69] each of whom expressed different points of view. Riedel described the operation which he employs. The hip is exposed through a lateral excision, with reflection of the greater trochanter. Then a wedge of bone is removed from the junction of the neck and femoral shaft, care being taken to preserve as many of the vessels as possible and to leave the capsule intact. The fragments are approximated and fixed with Schanz's screws. The trochanter is reattached at a more distal point than originally. Rost, on the other hand, stated that he has obtained excellent results by simple tenotomy of the adductor muscles. The results in patients examined from four to five years after the operation were almost ideal. The gait was nearly normal, and the patients did not complain of subjective disturbances in walking or running. Koenig thought that such an elaborate procedure as described by Riedel was unnecessary; that it was possible to dispense entirely with the use of internal fixative materials, and that Nature always took good care to straighten the fragments after subtrochanteric osteotomy of the femur.

[ED. NOTE.—Coxa vara may be due to so many conditions that we are unable to evaluate these statements without more precise knowledge of the type of coxa vara being discussed.]

Habitual Dislocation of the Patella.—In spite of the numerous operative methods for overcoming habitual dislocation of the patella that have been described, Hoffmeister[70] was unable to find any that gave active muscular power to the patella. Feeling the need of this in certain cases, he devised a method of transplanting the tendon of the gracilis muscle into the inner border of the patella. The method has been tried at Lexer's clinic in a number of patients with good results. The gracillis is exposed through a longitudinal incision on the inner side of the knee, cut as far distally as possible, and freed for a distance of from 8 to 10 cm. The free end of the tendon is then pulled beneath the sartorius muscle and fixed under considerable tension in a hole which is drilled in the medial border of the patella. Hoffmeister stated that it does not much matter whether the gracilis, the semitendinosus or the semimembranous is selected for transplantation.

Fusion of Paralytic Knees.—Miller[71] performed fusion operations on the knees of twenty-five patients with infantile paralysis, in whom

69. Riedel, Rost and Koenig: Zentralbl. f. Chir. **55**:948, 1928.
70. Hoffmeister, W.: Zentralbl. f. Chir. **55**:65, 1928.
71. Miller, O. L.: South. M. J. **20**:782 (Oct.) 1927.

it appeared improbable that there would ever be sufficient muscle recovery to enable the patient to go without a permanent brace or crutches or without using the hand to reinforce the quadriceps muscle. The age of the patients ranged from 9 to 16 years. The operation consisted in shearing off the articular cartilage from the femur, tibia and patella. The patella was used as a graft across the gap between the femur and tibia. The epiphyseal cartilages were not damaged. Ankylosis was obtained in all cases.

[ED. NOTE.—We believe, in general, that fusion of the knee in infantile paralysis is to be condemned, but there are special circumstances which occasionally may justify it.]

Injuries to Semilunar Cartilages.—Fagge [72] discussed the etiology of torn internal semilunar cartilages, particularly of the bucket handle type, which is commonest of all, and in his opinion perhaps primary to all other types. His conception of the sequence of events at the time of injury is that the knee is first abducted and the internal meniscus sucked toward the center of the joint; then the free thin edge of the cartilage becomes fixed, due to rotation in the joint, and with the extension which follows, the internal lateral ligament is pulled tense and the thick edge of the cartilage drawn away from the fixed internal edge, thus causing a splitting of the cartilage.

Operative Repair of Posterior Crucial Ligament.—Gallie and LeMesurier [73] described an operation for the repair of a torn posterior crucial ligament of the knee. The steps of the operation were as follows: 1. Through a long medial incision at the posterior aspect of the knee, the tendon of the semitendinosus was exposed and freed. It was detached from the muscle as high as possible in the thigh. 2. By way of the superficial portion of the split patellar incision, the insertion of the semitendinosus on the inner surface of the tibia was exposed and the detached portion of the tendon drawn through the front of the leg. 3. The lower portion of the posterior medial incision was then deepened and the space between the gastrocnemius muscles located and widened until the posterior ligament of the knee joint and the upper portion of the posterior surface of the tibia came into view. The head of the tibia was then drilled from behind forward, the point of the drill emerging near the insertion of the semitendinosus. The cut end of the tendon was then fastened into the butt end of a sharp pointed bodkin and passed through the drill hole to the back of the knee. 4. The knee joint was next opened by a split patellar incision and the interior exposed

72. Fagge, C. H.: Brit. J. Surg. **15**:273 (Oct.) 1927.

73. Gallie, William E., and LeMesurier, A. B.: Ann. Surg. **75**:592 (April) 1927.

by flexing the knee. The sharp pointed bodkin was then passed through the posterior ligament of the knee from behind forward and made to follow the course of the posterior crucial ligament. 5. A small incision was now made over the subcutaneous portion of the internal condyle of the femur and a hole drilled through to the intercondylar notch. The end of the tendon was threaded on a flexible wire probe and pulled out through this opening. 6. The knee joint was next placed in full extension, the tendon drawn taut, and its terminal end sewn down to the internal lateral ligament. The incisions were closed and the knee immobilized in a plaster casing. Plaster fixation was discontinued at the end of two months. The authors reported that at the end of three years the patient walked with a normal gait, had a full range of motion and had worked as an ordinary laborer. His only complaint is that the joint is a little weak, and this is explained by the fact that there is still a little excess of lateral and anteroposterior mobility.

[ED. NOTE.—The operation described appears to offer an ingenious answer to the perplexing question of how to repair a torn posterior crucial ligament. It satisfies the anatomic requirements better than any other procedure of which we have heard.]

Osteotomy of Malleolus.—Pieri [74] suggested a wedge shaped osteotomy of the external malleolus as a means of overcoming the residual varus deformity of the ankle after an old varus deformity of the foot has been corrected as thoroughly as possible. He employed the following technic: A cuneiform osteotomy of the external malleolus is performed, and a wedge of bone with its base external and with a width of approximately 1.5 cm. is removed. A transverse osteotomy of the internal malleolus is next performed from the inner side, the varus deformity of the ankle corrected, which closes the opening in the external malleolus and makes a wedge shaped gap in the internal malleolus into which he fits the wedge removed from the external malleolus. He reported satisfactory results in two patients and the roentgenograms were printed and showed good anatomic correction.

Operative Correction of Drop Foot.—Lambrinudi [75] noted that an operation to fix the os calcis to the astragalus with the latter in a position of permanent equinus, but with the foot at right angle alinement with the leg would be an effective means of checking foot drop. By a lateral J-shaped incision exposing the astragalus, os calcis and scaphoid, he removed the cartilage from the subastragalar joint. He then resected the lower portion of the scaphoid and the head and part of the neck of the astragalus in such a way that when the astragalus is tilted the forward edge may be locked under the scaphoid. The portion removed

74. Pieri, Gino: Chir. d. org. di movimento **6**:616 (Nov.) 1927.
75. Lambrinudi, G.: Brit. J. Surg. **15**:193 (Oct.) 1927.

from the front of the astragalus is reshaped and placed at its posterior surface to act as a block between that and the os calcis. The operation has been performed nine times, with seven successful results and two failures, the latter due to slipping of the anterior edge of the astragalus from beneath the scaphoid. The author stated that there should be good power in the gastrocnemius for this procedure to be effective.

Results of Stabilization of Paralytic Feet.—Campbell [76] reported the results in 213 patients in whom he employed his bone block operations. Of the patients, 104 were children and 109 adults. Of the 104 children, seventy-six met all requirements in determining the end-results, while in twenty-eight either sufficient time had not elapsed or the patient was not available for observation. In seventy-one of the seventy-six, excellent results were obtained, the bone block being effective and preventing plantar flexion by impingement of the block either against the posterior aspect of the tibia or the rim of the articular surface of the tibia. There were five failures, three of which were due to improper technic at operation as demonstrated by roentgenograms. The transplants were placed too far posterior to the ankle joint to be effective in preventing plantar flexion. In one a good result was apparent after a few months, but was followed by a gradual dropping of the foot downward, though the size and relation of the bone block were satisfactory. This relapse was apparently caused by increased relaxation of the ligaments of the ankle joint. In one, apparatus was apparently discarded too early, as the unorganized graft and callus permitted plantar flexion from the constant force of gravity. Campbell stated that the bone block method has been of value in practically all persons with paralytic deformities of the feet with the exception of cavus, calcaneous and calcaneovalgus. Stabilization of the foot has been rendered more positive by the bone block and by the additional fusion of the astragalus and calcaneous through the block.

FRACTURES

Review of Two Thousand Fractures.—Newell [77] published a review of 2,000 fractures in patients personally treated during the past seven years. In this group, there were sixty-four patients who were treated by open operation. The frequency of operation in respect to the different bones was fractures of the radius and ulna first, of the tibia and fibula second, and of the patella third. The fractures included all parts of the body, the lower extremity ranking first. There was only one instance of nonunion and only one of Volkmann's contracture. Open reduction was performed in almost all cases of fracture of the patella and in depressed fractures of the zygomatic arch. The author expressed

76. Campbell, W. C.: Am. J. Surg. **3**:62 (July) 1927.

77. Newell, E. D.: South. M. J. **20**:644 (Aug.) 1927.

the opinion that prolonged immobilization retards normal healing and function.

Disability and Cost of Industrial Fractures.—Gray,[78] the medical referee for California of the Aetna Life Insurance Company, made a study of the disability and cost of industrial fractures in respect to whether the patients had been treated by specialists or general surgeons. He summarized as follows:

> In conclusion, our tabulation shows that the surgeon who has been specially trained in the treatment of fractures produces far better results in serious fractures, but that the general surgeon does more efficient work with minor fractures. In major fractures the added cost produced by the specially trained surgeon is more than compensated by decreased disability. This is not true in minor fractures.

Operative Treatment of Fractures.—Discussing the treatment of persons with fractures by open operation, from the development of which he expects future progress in the treatment of persons with fractures, Scudder[79] stated his belief that under present conditions fractures can be divided into three groups: (1) Those never operated on, such as Colles' fractures, fractures of the clavicle, many fractures in childhood or the adolescent period, and many fractures occurring at birth; (2) those always operated on, such as fractures of the patella with wide separation of the fragments, fractures of the head or neck of the radius, with such displacement of the small proximal fragment that there would result without operation great limitation of pronation and supination, certain spiral and oblique fractures of both bones of the leg in the middle or lower third, fracture of the os calcis, in which the line of fracture enters the astragalocalcaneal joint, fractures of the olecranon with wide separation, fracture of the shaft of the radius with displacement and irreducible fracture of the shaft of the femur; (3) those in which operation must be looked on as of doubtful applicability, such as fractures of the humeral shaft above the middle and near the shoulder joint, of both bones of the forearm and, of course, many others.

Influence of the Surgical Experience During the Great War on Treatment of Persons with Fractures in Great Britain.—According to Bristow,[80] the World War taught three great lessons in the handling of fractures: first, the value of Thomas' splint; second, the necessity for the segregation of fractures, and third, the value of team work. The postwar experience has shown that there is great need for

78. Gray, R. N.: J. Bone & Joint Surg. **10**:27 (Jan.) 1928.

79. Scudder, C. L.: Indications for Operative Treatments of Fractures, J. A. M. A. **89**:1917 (Dec. 3) 1927.

80. Bristow, W. R.: Influence of War Surgery on Treatment of Fractures in Great Britain, J. A. M. A. **89**:1920 (Dec. 3) 1927.

these lessons to be appreciated today as in war time, both from the point of view of the best care of the patient and from the aspect of teaching.

Phenomena of the Early Stages of Bone Repair.—The results of fifteen years' observation of specimens coming to the Western Reserve Anatomical Laboratory and the conclusions derived from them concerning the phenomena of the early stages of bone repair were reported by Todd and Iler.[81] According to them, the principles of bone repair are simple and their application varied. The fragments show erosion and vascularity. Part of the erosion is due undoubtedly to removal of the bone devitalized in the actual process of fracture, part to the channelling of old bone adjacent to the fracture by the multiplication of blood vessels which are bringing the necessary pabulum for nourishment of the repair cells. On the eroded areas of the fractured and adjacent surfaces, subperiosteal and endosteal or cancellous, there appears a callus of varying texture, finely granular in immobilized fragments, lava-like in those which were permitted motion. By successive stages, this callus is transformed into a cancellous mass and later into tissue with haversian systems. Ensheathing and endosteal callus becomes reduced or eliminated and the former so modified that a cortical waxy surface is developed. Definitive callus, of course, remains and goes through the corticization process also. There is no difference in the actual speed of development of these stages in different areas or fractures, but it is natural that a complete fracture cannot be solidly bridged as quickly as an incomplete one. Hence, although the same features are to be observed in a complete as in a merely fissured fracture, and although they are to be found at the same date, the fissured or "greenstick" fracture will be completely healed in about twenty days, whereas a complete long-bone fracture may after the lapse of that time show large masses of heaped up lava-like callus with as yet an unbridged gap. An impacted fracture, say of a vertebral body, may be healed in thirteen days. Inequality of vigor in repair is characteristic of the several parts of any fracture. In certain specimens this can be directly referred to bone damage by stress or strain at the actual instant of fracture, but in others the probable cause is more obscure. Where the periosteum is elevated from the bone adjacent to a fracture the bone often is diminished in vitality, does not show erosion and does not take an active part in repair, although it is not dead and becomes ultimately passively incorporated in the new structural bone. It must not be inferred that the raised periosteum develops new bone. As a rule the cambium layer is destroyed, and new bone is formed at or over the stripped surface. Such instances are found more frequently in fractures of the ribs than in the long bones, and they never occur in vertebrae so far as the Western Reserve Anatomical Laboratory collection shows.

81. Todd, T. W., and Iler, D. H.: Ann. Surg. **86**:715 (Nov.) 1927.

Free movement of fragments does not inhibit the normal repair process, but if fractured ends of low vitality rub against each other, the bone fragments cannot rub against each other without becoming reduced in vitality and friction facets speedily develop which are similar to the occlusal and interproximate facets on the teeth. Such facets develop within two weeks after the fracture and are usually described as polished or eburnated areas. These are found most often in fractures of the ribs but may occur in long bones. Endosteum or cancellous tissue is of great importance in bone repair. Compact tissue takes little part compared with the endosteum and cambium layer in the formation of new bone. It acts as the scaffolding on which the new bone is laid down. When cancellous tissue is relatively most abundant and mobility feeble or absent, repair is quickest, namely, in vertebrae and in fissured and "greenstick" fractures.

Fractures About the Elbow.—Sixty patients with fractures about the elbow were studied by Conwell.[82] Only two of these were treated by open reduction. In the author's opinion, open reduction should be performed only when repeated attempts at manipulative reduction fail. He does not consider the presence of swelling about the elbow a contraindication to immediate closed reduction. He fixes the elbow by a special type of traction apparatus and permits active motion, as soon as the patient is able, to the limit permitted without pain.

Allison[83] laid down the following rules for the treatment of persons with fractures about the elbow:

1. Always give consideration to three factors in fractures of the elbow: (*a*) injury of the bone; (*b*) injury of the nerves, and (*c*) circulatory damage.

2. Haste is unnecessary. Take roentgenograms of the region of injury in two planes. Get a rough estimate of the condition of the peripheral nerves and record it. Form an estimate of the condition of the circulation in the forearm and hand and record it.

3. For the treatment of simple fractures, acute flexion is the rule, but before fixing the elbow, make sure that the fracture is reduced. Watch the circulation of the hand.

4. Difficult fractures of the elbow involving the joint, including those with much comminution or displacement or with accompanying dislocation, require hospitalization and the utmost of surgical skill.

5. In the after treatment, use of the part should be permitted and active exercises encouraged. "Pump handle" manipulation should be avoided.

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82. Conwell, H. E.: South. M. J. **20**:579 (Aug.) 1927.

83. Allison, Nathaniel: Fractures About Elbow, J. A. M. A. **89**:1568 (Nov. 5) 1927.

Hansson and Birrell,[84] of the Department of Physical Therapy of the Hospital for Ruptured and Crippled Children, compiled the results of the after treatment in 100 patients with fractures about the elbow who were seen successively. Of these, 14 were treated by open reduction. Among the patients with complications were two with myositis ossificans, one of whom was discharged with 87.5 per cent and the other with 81 per cent of normal function. The authors concluded from their study that immobilization of fractures about the elbow carried on for more than a month is responsible for long after-treatment and incomplete return of function, and that physiotherapy may be safely begun at the end of two weeks. In their opinion, massage and passive motion are unphysiologic and are contraindicated. Any treatment by physical means that may require one hour out of twenty-four or forty-eight hours is insufficient and of little avail if it is not followed up by exercises at home which can be repeated every two or three hours. In spite of the best efforts at reduction, as well as after-treatment, about 10 per cent of the fractures about the elbow will yield poor end-results.

Fractures of the Lower End of the Radius.—Study of end-results in 206 out of 242 patients with Colles' fracture treated at the polyclinic of the municipal hospital of Copenhagen, during the four year period from 1921 to 1925, was made by Eskalund.[85] Fracture of the styloid process was found in 46 per cent and fracture lines extending to the articular surface in 12 per cent of the cases. The treatment consisted in reduction—as a rule, without an anesthetic—and the application of a dorsal plaster splint to the pronated wrist in extreme flexion and ulnar deviation. After from six to eight days of immobilization, the splint was removed and massage begun. The end-results in this group of patients were listed as follows: functional results, excellent, 60 per cent; good, 33 per cent; fair, 6 per cent; poor, 1 per cent; anatomic results, excellent, 55 per cent; good, 36 per cent; fair, 9 per cent; poor, 0 per cent. The treatment covered a period of from six to eight weeks on an average; seventeen patients required treatment for more than fourteen weeks.

Compression Fractures of the Spine.—Osgood,[86] writing on the diagnosis and treatment of persons with compression fractures of the spine, summarized as follows:

1. One should always suspect compression fracture in all spinal injuries. The condition is usually missed. In only seven cases of Wallace's series, did he obtain charge of the patient early, and in 47 of the remaining 67, or 70 per cent, the diagnosis had not been made before he saw the patient. Sever, reviewing 24

84. Hansson, K. G., and Birrell, R. G.: Am. J. Surg. **3**:13 (July) 1927.

85. Eskalund, V.: Acta chir. Scandinav. **62**:41 (July 28) 1927.

86. Osgood, R. B.: Compression Fractures of Spine, J. A. M. A. **89**:1563 (Nov. 5) 1927.

industrial cases of compression fracture, found that the minimum period of disability before the case was seen by an impartial referee was 17.7 months.

2. When suspicion is aroused it should be confirmed or allayed by accurate roentgenologic films taken in both the anteroposterior and the lateral plane; if doubt remains, stereoscopically as well.

3. Complicating fractures of the laminae, transverse processes or of the ribs and of the bones of the extremities, especially of the os calcis, are often present and influence treatment.

4. In early uncomplicated cases, adequate nonoperative methods may be expected to restore full wage earning capacity.

5. In old cases presenting symptoms, the reduction of the postural faulty mechanics may be expected to relieve the pain and in many cases, the disability as well. If nature has not ankylosed the injured region of the spine, and the patient is to return to back bending labor, ankylosing operations after the faulty mechanics have been corrected are likely to save time and allow the patient to labor without apprehension.

Fractures of the First Cervical Vertebra.—Jefferson [87] collected reports of sixty-five cases of fracture of the atlas. He pointed out that in thirty-two cases reported since 1900, only five patients died. The advent of the roentgen ray, making diagnosis possible, has led to an apparent reduction in the number of deaths. The location of these fractures was as follows: anterior arch alone, eight cases; posterior arch alone, twenty-nine cases; both arches, twelve cases; lateral mass, seven cases; transverse process, three cases. A longitudinal compression of the head on the spine was the most common cause of this injury. The complicating injuries were fracture of the odontoid process (seventeen cases), rupture of the vertebral artery, rupture of the great occipital nerve and injury to the spinal cord or medulla.

Late End-Results in Ununited Fracture of the Neck of the Femur Treated by the Bone Peg or Reconstruction Operation.—The end-results of the operative treatment in 146 cases showing ununited fracture of the neck of the femur were reviewed by Albee [88] and summarized as follows:

Five patients were seen early and treated by the Whitman abduction spica with excellent results. Thirteen cases had to be eliminated because of incomplete records. In forty-two of the remaining 128 cases the bone peg operation was recommended; in fifty-three, the reconstruction operation. Six of the former refused operation, and nine of the latter, leaving a total of eighty patients (36 bone peg and 44 reconstruction operations).

In ninety per cent of the bone peg operations the results were excellent or good, and in seventy-five per cent of the reconstruction operations. The interval between the time of operation, and that of the last examination varied from a few months to fifteen years. Function is usually good within six months after operation. When we consider that ununited fracture of the neck of the femur

87. Jefferson, Geoffrey: Brit. M. J. **2**:153 (July 30) 1927.

88. Albee, F. H.: J. Bone & Joint Surg. **10**:124 (Jan.) 1928.

is one of the most disabling of all traumatic lesions, and one of the most difficult problems in surgery because of the anatomicomechanical conditions and because of the erosion that has so often taken place before the surgeon is consulted, such end-results are most encouraging.

Fracture of Internal Condyle of Femur.—Rongoni [89] reported two cases of fracture of the internal epicondyle of the femur. He believed both to be due to reflex muscular contraction of the adductors in an attempt to prevent the occurence of a valgum position of the knee. The injury was recognized from roentgen-ray examination, and the author emphasized the necessity of careful roentgenologic examination of the knee in every case of injury. Conservative treatment was followed and, according to the author, is all that is indicated.

Old Infected Compound Fractures of the Tibia.—A method of treatment of old infected compound fractures of the tibia was described by Thornton,[90] as follows: "The infected area is resected by a primary operation and wound allowed to heal. A brace is worn 'during that period of time when latent infection may be present.'" When this danger has passed, a massive inlay bone graft is made to bridge the bony defect at the site of fracture. From ten to twelve months are usually required between the primary and secondary procedures, and the longer the delay, the less danger there is of stirring up latent infection. The graft is large, broad and sliding; if it cannot be obtained from the fractured tibia, it should be taken from the opposite leg. The author did not mention the number of patients treated by this method but did state that it "has given uniformly good results."

Treatment of Fractures of the Os Calcis by Arthrodesis.—From a study of twenty-six patients with twenty-eight fractures of the os calcis, who were treated by subastragalar arthrodesis, Wilson [91] stated his belief that in old cases of fracture of the os calcis with continued pain and unsatisfactory progress, the cause of the disability was usually to be found in a traumatic arthritis resulting from a disruption of the subastragalar joint. If the evidence obtained from a clinical and roentgenographic examination warranted this diagnosis, then relief of the condition was to be obtained by the operation of subastragalar arthrodesis. At the same time, all bony irregularities at the lateral aspects of the os calcis should be removed.

Replying to the question, Is not the disability which is created by ankylosis of the calcaneo-astragalar joint as disabling as the condition from which the patient originally suffered? Wilson said that irrespec-

89. Rongoni, L.: Policlinico **34**:421 (Sept. 15) 1927.

90. Thornton, L.: Surg. Gynec. Obst. **45**:385 (Sept.) 1927.

91. Wilson, P. D.: Treatment of Fractures of Os Calcis by Arthrodesis of Os Calcis Joint, J. A. M. A. **89**:1676 (Nov. 12) 1927.

tive of the method of treatment used, a great amount of motion does not result in any case. In the author's experience, the disability due to ankylosis of the subastragalar articulation, provided the foot was in good weight bearing position, was scarcely recognizable. The tarsal joints developed compensatory hypermobility which gave a fair semblance of the lateral motion of the foot, and heavy work could be done without complaint.

Fracture of Fifth Metatarsal Bone.—By means of a report of twenty-one cases, Carp [92] illustrated the tendency which he has noted for a fracture of the fifth metatarsal bone to exhibit delay in healing. He ascribed the tendency to a deficient blood supply. Of these patients, twenty were adults and five showed clinical and roentgenologic evidence of delayed union. All the other patients had clinical symptoms over such long periods that the author thought it fair to assume some interference in bone repair in their cases also. By way of treatment, the author suggested immobilization of the foot and leg by a molded plaster splint and, when possible, weight bearing in the splint before the end of one month.

DISLOCATIONS

Pathologic Dislocation of the Hip Joint.—Putti and Zanoli [93] reviewed the subject of pathologic dislocation of the hip joint resulting from acute infantile arthritis. They discussed the diagnosis and pathologic changes of the condition and reported fifteen cases with end-results. They considered that closed reduction is usually impossible, contrary to the opinion of the French authors. They described the four methods of intervention employed by them as follows:

1. Reconstruction of the epiphysis and neck of the femur by means of a free bone transplant, the head and neck of the fibula being used (one case).

2. Reduction of the greater trochanter into the acetabulum, followed by subtrochanteric osteotomy to reform the femoral neck (three cases).

3. Simple reduction of the epiphyseal stump (five cases).

4. Plastic reconstruction of the femoral neck (method of Whitman, seven cases).

The authors concluded that Whitman's method is the one chiefly to be recommended.

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92. Carp, L.: Ann. Surg. **86**:308 (Aug.) 1927.

93. Putti, V., and Zanoli, R.: Chir. d. org. di movimento **6**:539 (Nov.) 1927.

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